MAY 1960

Agricultural Engineering

The Journal of the American Society of Agricultural Engineers

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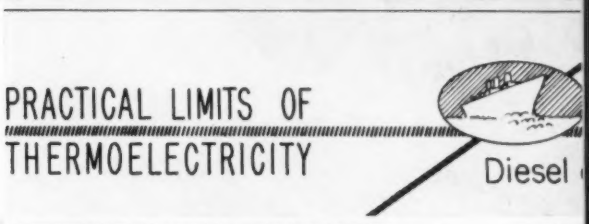

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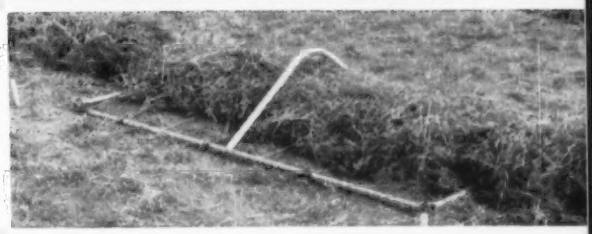

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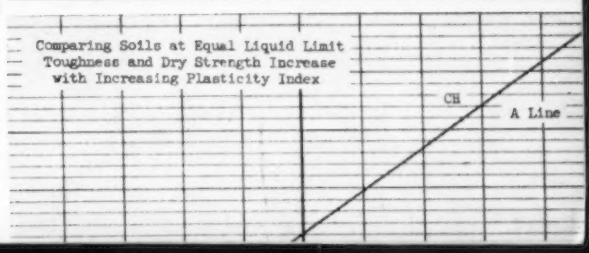


CASE HISTORIES

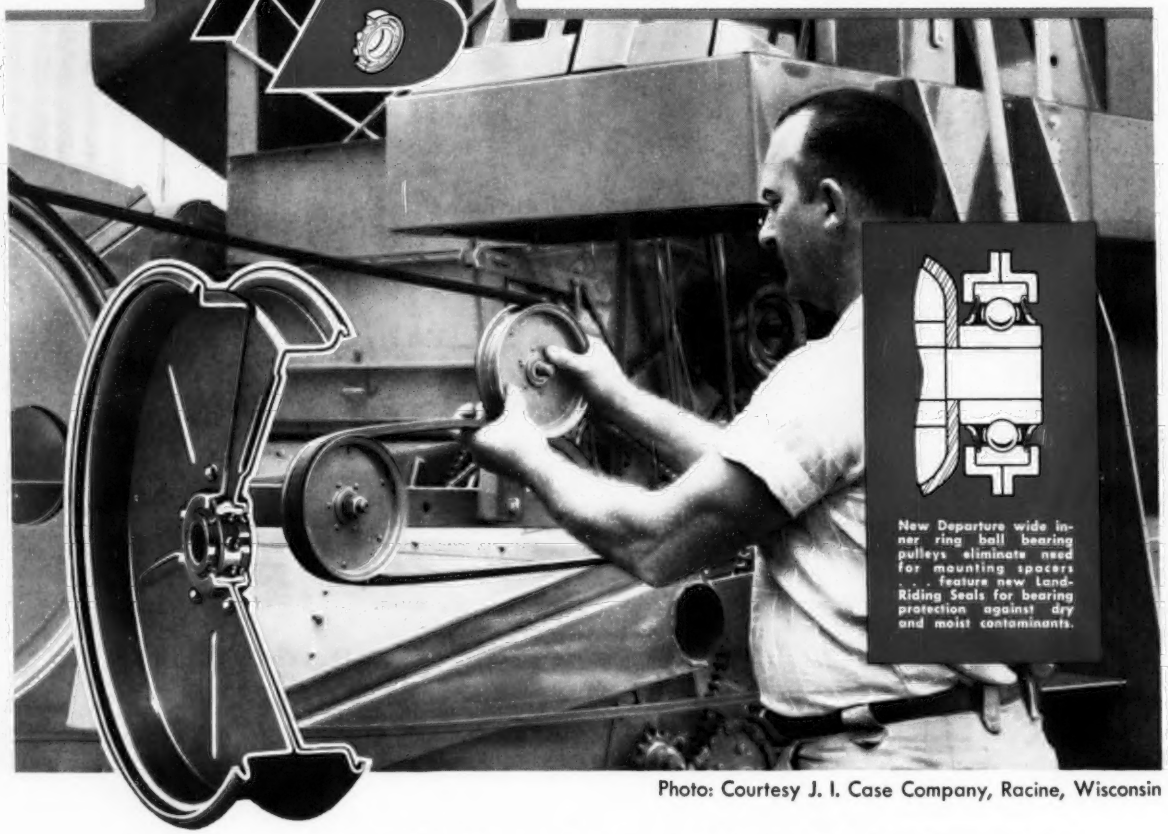

New Departure wide inner ring ball bearing pulleys eliminate need for mounting spacers . . . feature new Land-Riding Seals for bearing protection against dry and moist contaminants.

Photo: Courtesy J. I. Case Company, Racine, Wisconsin

Idler Pulley Assemblies Help Combine Manufacturer Cut Inventory & Assembly Costs!

CUSTOMER PROBLEM:
Leading farm implement manufacturer experiencing rising costs in the installation of ball bearing pulleys on combines and other farm implements.

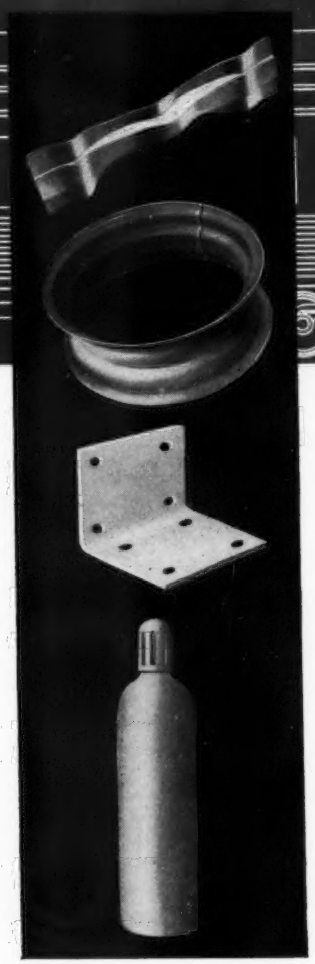
SOLUTION:
N/D Sales Engineer, in cooperation with the manufacturer, made an evaluation of pulley applications. He then recommended N/D Land-Riding Seal pulley assemblies containing ball bearings with *wide* inner rings. The wide inner ring paved the way to cutting costs by eliminating conventional spacer inventories. Moreover, the manufacturer now enjoys additional savings because N/D Lubricated-for-Life ball bearing pulleys are *fully assembled* at delivery . . . simplifying inventory even more!

The wide inner ring bearing, butt mounted rigidly against face plate, requires a minimum of parts handling and adjusting at assembly. In addition, these 8" O.D. pulleys have rolled sheave edges for belt protection. All pulleys come with the new and exclusive N/D Land-Riding Seals, factory greased, ready to offer full maintenance-free protection against dry and moist contaminants.

If *you're* a user of flat and "B" section V-Belt pulleys, sizes from 2¾" to 8" O.D., why not check on the savings N/D has to offer? Contact your local N/D Sales Engineer or, write today for the new N/D Idler Pulley Bulletin giving complete specifications and mounting data. New Departure Division, General Motors Corp., Bristol, Conn.

Replacement pulleys available through United Motors System and its Authorized Bearing Distributors.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around



Columbium flat-rolled steels

Do you need a steel, to use in the "as rolled" condition? Or a steel which has high strength, good weldability, good formability?

More and more manufacturers are turning to columbium flat-rolled steel products, for columbium sheet, strip or plate gives an answer to all of these requirements.

Here are just a few examples of columbium steel's wide versatility. Line pipe for gas and oil offers ease of manufacture with excellent physical strength. Trucks, automobiles, farm implements, trailers and railroad cars take advantage of strength and ease of formability. Pressure vessels utilize the deep-drawing qualities of the steel. These applications and many others tell the story of columbium steel's versatility—and all with fewer rejects.

In the face of mounting manufacturing costs, columbium steels offer hope of effecting economies in producing your products. Ask any steel company for they can make it. Or ask us—we have a wide experience in its uses and knowledge of its manufacture.

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MCA

Agricultural Engineering

Established 1920

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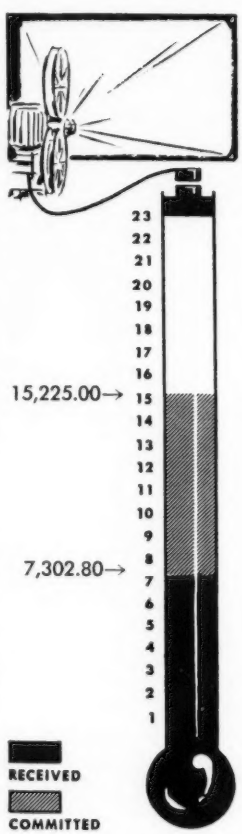
ASAE Motion Picture Report

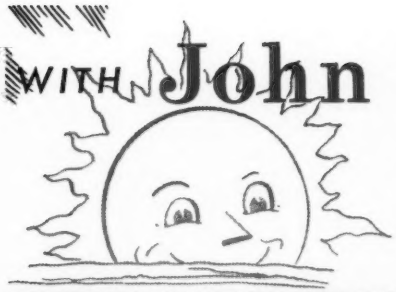
AN unexpected surprise concerning the ASAE Motion Picture fund, and one that creates somewhat of a problem in giving proper credit, especially in crediting the appropriate category, developed during the month. It all came about when Philip Wendell, through the courtesy of the American Planter Company of Burr Oak, Michigan, attended a recent meeting of Canadian extension agricultural engineers at Western Ontario Agricultural School, Ridgetown, Ontario, Canada, to discuss materials handling problems. Following the unusually interesting presentation, typical of those given by Phil, the group took up a collection to help defray Phil's travel expenses. Although Phil explained that his expenses were all arranged by John Reed, president of his company, the group insisted that he keep the money as a token of their appreciation. Being quick to recognize a solution to the problem that would satisfy all, Phil accepted the contribution in behalf of the ASAE Motion Picture Fund. Since I am sure our bookkeepers will be able to resolve the problem of properly crediting the entry on the books, we want to be sure that we credit all those who participated. — Thanks to all the Canadian extension agricultural engineers and John E. Turnbull, member of ASAE, who presided during the meeting; thanks to John Reed and last but not least to Phil Wendell.



The Cabinet Meeting, to be held Sunday, June 12, during the ASAE Annual Meeting, will be devoted to various career promotion activities. A five-step plan of activity developed around the ASAE motion picture will be described in detail and copies of various pieces of promotional literature will be displayed during the meeting.

Since the Cabinet Meeting will be devoted to career promotion, in addition to the motion picture, it will be open to all ASAE members. If you are going to be in Columbus Sunday evening, plan to attend.

Production of the film is progressing on schedule. The Production Committee and other ASAE members in the Washington, D.C., area met on May 2 to review the film and were enthusiastic in their comments about the picture. Final editing is being completed and prints will be available for delivery by June 20. ASAE members will have an opportunity to witness a premiere showing of the film, which is scheduled as a feature of the ASAE annual banquet to be held, Wednesday, June 15.



WITH **John Deere Hay Tools**

there's always something new under the sun...

The new 10 Side-Mounted Mower provides big capacity, easy mounting, up-front vision and a host of other outstanding features.

Feeders and dairymen everywhere watch closely for "what's new" in John Deere Haying Equipment. There's always something new to make work lighter . . . profits bigger.

This year is no exception. They're "taking to" the 10 Side-Mounted Mower with its big capacity and up-front view . . . the Swath Fluffer that speeds curing at low cost . . . the 858-A Rake with its new, flexible Rubber-Ball-Joint Teeth . . . the 214-WS Wire-Tie Baler with its simple John Deere Single-Twist Knotter that ties with greater accuracy . . . the 200 Bale Elevator that works as an elevator, a conveyor, or both . . . and the 300 Regular and 350 Heavy-Duty Portable Elevators that handle bales lying flat.

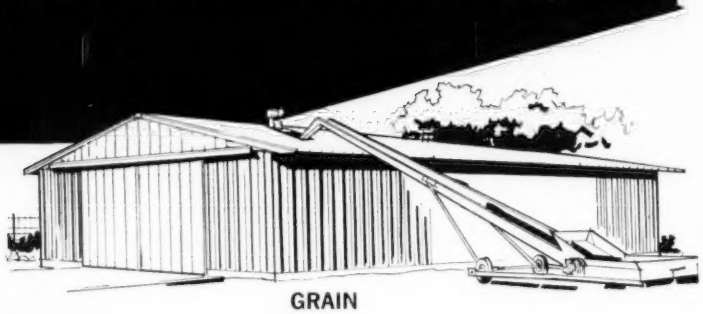
The "something new" keeps dealers up to date, too. And that's another reason why the John Deere franchise is the most valued in the industry.

JOHN DEERE
3300 RIVER DRIVE
MOLINE, ILLINOIS

"WHEREVER CROPS GROW, THERE'S A GROWING DEMAND FOR JOHN DEERE FARM EQUIPMENT"

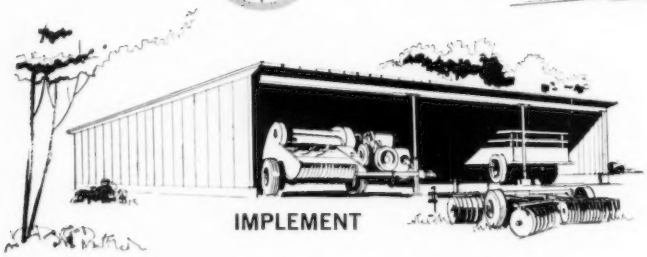
ARMCO BUILDINGS

Help increase farm efficiency



GRAIN

Steel

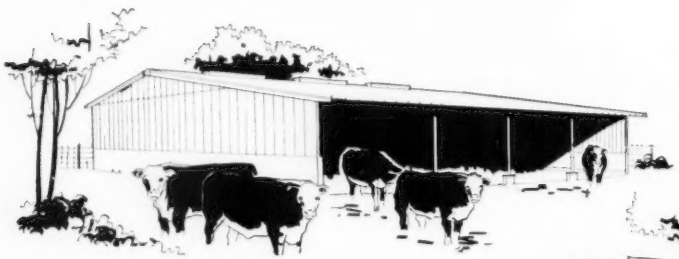


IMPLEMENT

Armco's complete range of sizes and building types helps make farm layout and arrangement easier, more efficient. There's an Armco Building for *every* farm need. And these factory-produced buildings enable agricultural engineers to spend more of their time on systems for labor-saving and product quality, less time on the structures themselves. Find out more about the advantages of rugged, durable Armco Buildings.

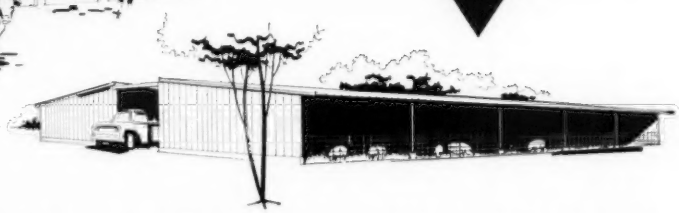
Write for the Armco Farm Building Catalog. Armco Drainage & Metal Products, Inc., 6320 Curtis St., Middletown, O.

DAIRY



LIVESTOCK

New steels are born at Armco



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TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

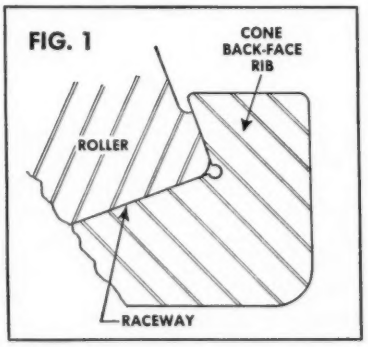
BEARING BRIEFINGS

BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

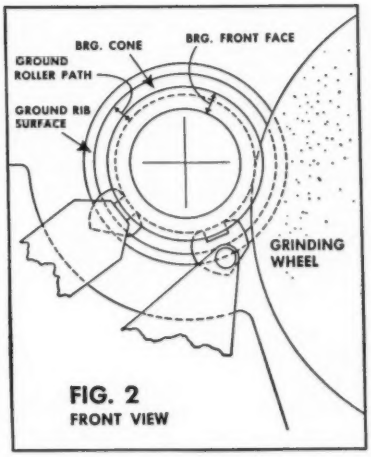
To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

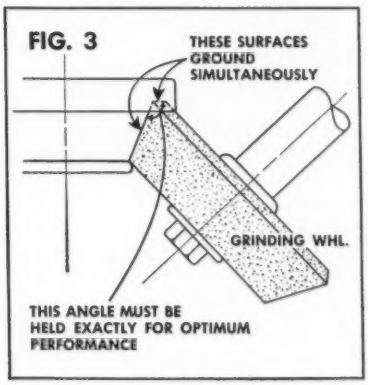


In the design and manufacture of Bower tapered roller bearings, Bower engineers take great care to generate and hold an exact face angle on the cone back-face rib. In practice, this means that Bower bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.



It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.



★ ★ ★ ★

When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Report to Readers . . .

ENGINEERS SEEK BEST RECIPE FOR MAKING HIGH-QUALITY HAY WAFERS

USDA agricultural engineers have reported on a study made last season in cooperation with Maryland AES researchers, of wafering several kinds of long forage direct from windrows. The study was made to develop means of reducing hay bulk to facilitate mechanical handling with minimum hand labor. . . . Best results were obtained when the forage was of uniform dryness and bulk in the windrow. Best quality wafers were made from forage containing 10 to 14 percent moisture. It was found that wafers up to 14 percent moisture content could be stored safely at depths less than 7 feet. More study is needed to determine drying requirements for high-moisture wafers. Also, the agricultural engineers want to find out what temperatures, humidities, and storage conditions cause heating and mold formation in stored wafers. . . . Significantly, the researchers appear to consider wafering a more desirable method of field-processing chopped or long forage for dairy cattle than pelleting hay that has been finely ground.

CONFINEMENT REARING OF MARKET HOGS PROFITABLE SAY ENGINEERS

Iowa SU agricultural engineers say that market hogs can be finished (50 to 200 pounds) faster in confinement production, also that the year-round use of such production facilities makes it possible for the farmer to produce three hogs in the time it formerly took him to produce two. The Iowa studies show that mechanization reduces labor time to an average of only 30 minutes per head during the growing-finishing period. It is also reported that Danish research has shown that pigs reared in confinement may produce better meat. Whereas the pig grown outdoors uses some of his protein for heat, the confined pig under temperature-controlled conditions uses more of his protein to produce meat.

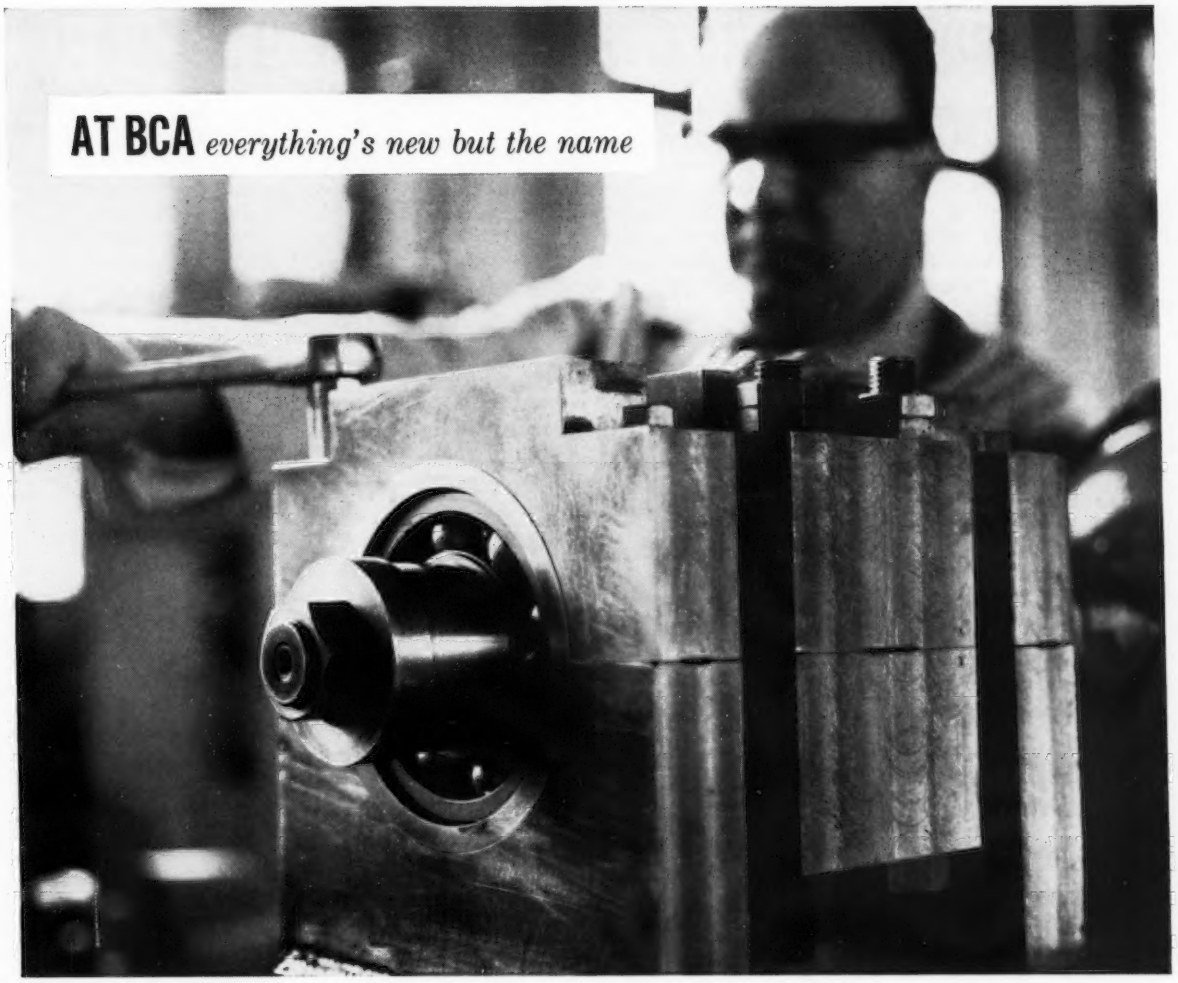
MORE BASIC AND APPLIED RESEARCH ON TILLAGE EQUIPMENT RECOMMENDED

A research advisory group serving the Agricultural Research Service of the U. S. Department of Agriculture has recommended that federal research programs dealing with tillage equipment be expanded. The particular subjects or areas which need to be emphasized include (a) a study of the relationship between tillage-implement characteristics and soil behavior as a basis for developing the fundamentals for improving tillage equipment design and use; (b) a determination of the factors that produce compacted surface and subsoil layers and their effect on movement of air and water into and through soil and on root development; (c) a determination of the relation of speed of operation to power requirements, and (d) the development and adaptation of tillage machines to meet the peculiar requirements of conservation farming.

CHEMICAL CONTROL OF SEEPAGE FOR REDUCING IRRIGATION WATER LOSS

USDA agricultural engineers are hopeful that a relatively cheap chemical means can be developed that will prevent most of the water seepage losses that now are as much as 40 percent on some irrigation projects. In recent tests at the new federal water-conservation laboratory in Arizona, these engineers have found that a minimum rate of zero infiltration was achieved after one-half inch or so of the surface soil has been treated with "hydrophobic" metallic (sodium) soap. . . . Mixing the soap with a layer of surface soil, while presenting no problem in the laboratory, would be much more difficult on a commercial scale. The researchers are arranging to try various expedients for this purpose. Also, in addition to sodium soap, these studies will include calcium soap, magnesium soap, silicones, asphaltic emulsions, and other water-repellent materials. . . . The USDA engineers point out that chemical seepage control is not new and give full credit to pioneers in that field, including the California originators of "SS-13," U. S. Bureau of Reclamation, and others.

(Continued on page 272)



NEW "TORTURE CHAMBER" FOR RADIAL BEARINGS

duplicates military acceptance tests

This is a torture chamber for radial bearings. Here BCA ball bearings are run . . . hour after hour . . . under loads of 5000 pounds per bearing — matching military acceptance tests for radial bearings. This special BCA-built device is an important control and development tool. It provides essential data for BCA's ball bearing research program.

This tough performance test is an example of the greatly expanded research and testing facilities which BCA has developed for the benefit of bearings users. Reason: to provide the finest possible ball bearings to customers. Results: bearings which consistently exceed performance specifications on whatever kind of jobs they are designed for.

Among the extensive new facilities at the BCA laboratories is a Temperature-Humidity-Controlled Instrumentation Room containing precision instruments, many of which have been specially designed and modified for bearing research. There are a number of unusual testing devices, too; in design, identical to equipment in customers' plants. On these, BCA bearings can be tested *under the exact operating conditions specified by the customer.*

BCA provides a complete line of ball bearing sizes and types for nearly every kind of industry. They're standard original equipment on automotive, machine tool, earth moving, and agricultural equipment, for example. And, you'll find BCA a dependable source not only for high-performance ball bearings but engineering assistance, should you need it. For more information, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

. . . Report to Readers (Continued from page 270)

HOSE REEL DESIGN USED IN PICKUP BALE LOADER — Having much the appearance of an oversize hose reel is a gearless bale loader developed in England for gathering and loading bales in the field. This wheel-like device is 9 feet in diameter and has two hoops 2 feet or so apart on which are arranged 48 weighted hooks, twenty-four on each side. As the open framework of the wheel passes over a bale, the hooks drop, grip the bale, carry it upward, and at the top of the wheel release it automatically onto a roller platform form where it is removed for stacking on a truck or wagon trailed alongside.

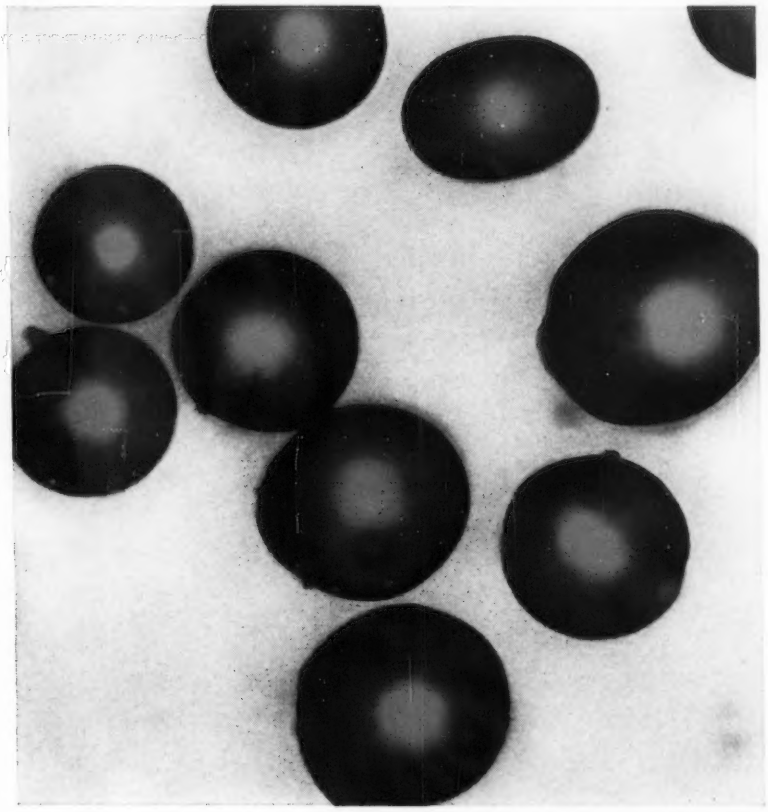
GRANULAR INSECTICIDES SIMPLIFY EQUIPMENT CONTAMINATION PROBLEM — A Cornell University researcher directs attention to the particular advantages of granular insecticides, especially in connection with speeding up the application operation. The granular form, in addition to simplifying the problem of contamination and cleanup of equipment, also eliminates the water problem, including the plugging of nozzles. Applicators for granular carriers cost less to do the same job, and band application is possible with much greater facility than is the case with spraying.

PORTABLE PLASTIC DITCHES UNDER STUDY FOR SURFACE IRRIGATION — A research chemist for one of the major farm equipment manufacturers told a meeting of agricultural engineers that portable plastic ditches have been developed for surface irrigation of land under heretofore impossible conditions. The ditches, made from large-diameter, easily portable tubing, are said to make irrigation possible where the required land grading for standard surface irrigation would be impractical or impossible. . . . It is said that this development is also prompting research study into the use of low-cost, collapsible plastic tubing for high-pressure sprinkler irrigation. Such systems now under development are intended to provide more economical irrigation for orchards and such tall crops as corn, tobacco, etc.

PADDLEWHEEL ASPARAGUS PICKER DEVISED BY MICHIGAN INVENTOR — This picker, developed in southwestern Michigan, is essentially a snapping machine. Its main feature is a reel, or paddlewheel, which revolves at ground speed as the picker is pulled down the row. The wooden paddles, which make up the paddlewheel, press against the asparagus spears in one direction as the snapping bar on the machine meets the base of the spears from the opposite direction. The revolving paddle then snaps these spears over the bar and carries them up an incline behind the snapping bar. At the top of this incline, the spears fall over the back into crates carried on a rear deck. . . . . The machine snaps all spears that stand more than approximately two inches above-ground. While this may cause some reduction in yield, it is believed it will be more than offset by the lower harvesting cost the machine is expected to make possible.

BETTER INTEGRATION OF FARM CHORE OPERATIONS AND RELATED EQUIPMENT — An urgent need in connection with mechanizing so-called "farm chore" jobs is to achieve best possible integration of the various equipment items used with the operations to be performed. "Too many kinds of equipment to choose from without a workable system for using them is the big problem for many farmers in mechanizing their chore jobs" comments one agricultural engineer. . . . The farmer's problem is not simply one of selecting various equipment items needed to mechanize his chore jobs. Rather it is a matter of using his best judgment in deciding what available equipment, singly and in combination, will enable him to provide himself with the most workable and otherwise satisfactory system for his needs. . . . To assist him in such endeavor, the farmer can always consult the agricultural engineers of his state agricultural college and of the federal department of agriculture for sound information and advice on farmstead equipment systems. The more urgent need, it would seem, is for specialized equipment dealers who are competent to understand the problems of individual farmers and to assist them with plans that may combine engineering, equipment, and management considerations.

30 MILLION OF THESE JET-FORMED SPHERES IN EVERY INCH OF BEARING SURFACE!



JET PROCESS BLASTS MOLTEN ALLOY INTO UNIFORM PARTICLES . . . so small that thirty million will form a thin layer only one inch square! This sintered layer is the bearing surface of Federal-Mogul sleeve bearings.

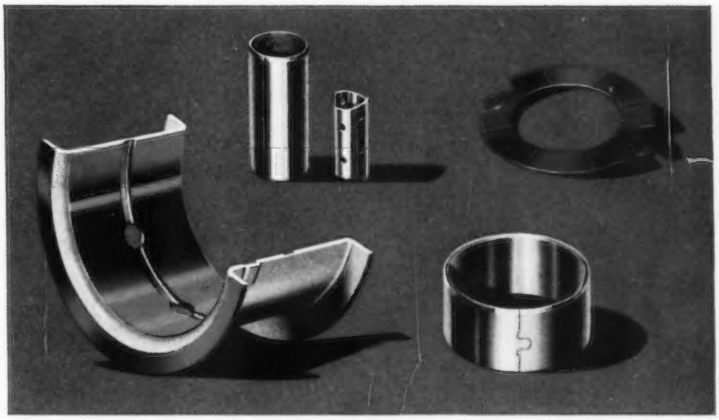
Molten copper-lead, alloyed to exact specifications, is poured into a special inert-atmosphere reaction crucible. Here it's blasted by a high-speed fluid jet to form the dense powder shown at left.

Because of the uniform particle size of this powder, the bearing surface of each F-M copper-lead sleeve bearing has precisely the same alloy composition and high adhesion to the steel backing as every other F-M bearing of the same alloy type!

YOU CAN SEE THE CONSISTENT SIZE in the photomicrograph. What you *can't* see is the consistent alloy composition which produces uniform bearing properties and performance in any alloy type.

Federal-Mogul makes engine bearings for every condition of speed and load. You can select from among five different sintered copper-lead alloys, all permanently bonded to precision-formed steel backing. Our Engineering Department is available to you for consultation or recommendations on bearing design and application. For more information, write Federal-Mogul Division, 11081 Shoemaker, Detroit 13, Michigan.

FEDERAL Mogul



A COMPLETE LINE! Steel backed bearings with a selection of many different alloys for virtually any bearing application—Plain and bimetal bushings in bronze, steel or aluminum. Precision thrust washers in solid bronze, or sintered alloys on steel (one or both faces). Rolled split spacer tubes in steel, aluminum or stainless.

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sleeve bearings
bushings-spacers
thrust washers

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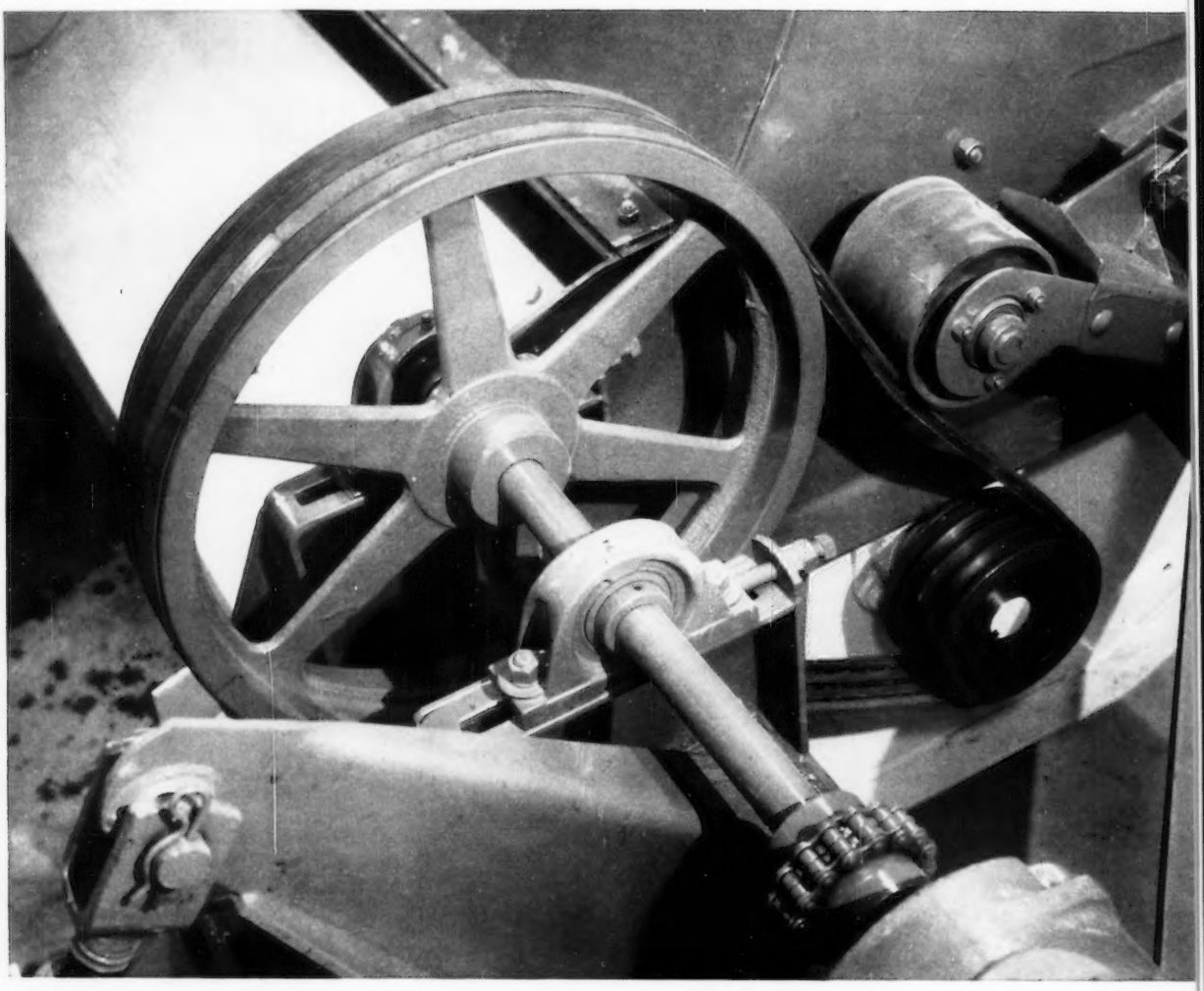

"Four Dayton Die-Cut V-Belts Out Perform 6 Standard Belts"

"Belt slippage and failure constantly plagued us when we used conventional V-belts on the pilot model of our Super 60 Forage Chopper," says Mr. Vernon Lundell, Pres., Lundell Mfg. Co., Cherokee, Iowa. "We faced the possibility of having to redesign the drive from a 4 Belt to a 6 Belt unit to get the power we needed."

"Our engineers consulted the Dayton representative who recommended a *Dayton Die-Cut, Agricultural V-Belt.* It was the perfect answer. The Dayton Belt easily transmits up to 40% more horsepower than any other belt we have ever tested. Its high coefficient of friction (due to Dayton's exclusive Die-Cut construction) eliminated slippage completely . . . thus solving once and for all the friction and heat conditions which materially reduce the work-life of any V-Belt."

"Exhaustive testing by our engineers has proven that four Dayton Die-Cut V-Belts will actually out-perform a drive system using six conventional V-Belts. That is why we use Dayton V-Belts exclusively and highly recommend them for production line replacement and quick substitutes in the field."

The Lundell Super 60 Forage Chopper performs a wide variety of jobs including hay pick-up from windrow; cutting broadcast cane, alfalfa and brome; grinding corn, etc. This versatility is accomplished by means of quick change cylinders with various sizes of driven sheaves to control speed of operation. As a result the Belts have to handle many different loads and a wide range of speeds.

In the nine years since Lundell Mfg. Co. started using Dayton Die-Cut Agricultural V-Belts not a single one has ever broken. "We know of no other V-Belt that can even begin to match this outstanding performance."

The Dayton Die-Cut Agricultural V-Belt has no cover to wear out . . . is specially compounded to continually renew its gripping surface as it operates (whereas conventional fabric-covered belts on this type drive wear smooth and slip). Abrasive materials . . . chaff, mud, chips, stone and metal particles . . . which tear covers and ruin other belts . . . have no such effect on the Dayton Die-Cut Agricultural V-Belt, and can actually **add** to its gripping strength.

Dayton manufactures a complete line of V-Belts for all types of agricultural drives. For assistance with your standard or special V-Belt drives call your nearest Dayton representative or write to:

INDUSTRIAL DEPARTMENT

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Dayton Industrial Products Co.

2001 Janice Avenue Melrose Park, Illinois A Division of The Dayton Rubber Co.

How to get new attachment ideas "off the shelf"

You literally pick new chain attachment ideas right off the shelf when you call in your Rex Agricultural Chain Engineer. He brings to your development program the industry's most complete line of attachments. Here you'll quickly find the exact type you need to solve the toughest implement problem. Or you'll find a type that sparks the idea for just the special attachment you need.

A prototype is in your hands quickly because CHAIN Belt's engineering and production facilities are geared for special service. Many of today's popular standard attachments were developed as Rex "overnight" specials—products of CHAIN Belt's ability to move quickly and surely in designing and producing the right answers to your implement design problems.

Invite your Rex Agricultural Chain Engineer in when he can be most helpful—at the planning stages. He's equally at home in the field and beside the drawing board.

Contact your local CHAIN Belt district office. CHAIN Belt Company, 4681 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto.

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New
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BLOOD BROTHERS

JOINTED DRIVE ASSEMBLY

Farmers are getting faster, easier, cleaner hay harvesting and better-quality hay with this new Allis-Chalmers No. 77 parallel-bar side rake. It makes straight, airy windrows for easier baling. Its power take-off drive permits the operator to adjust reel speeds for best performance under any crop or field condition . . . to assure a clean, leaf-saving pickup every time. And an important drive component in this advanced new rake is a Blood Brothers jointed P.T.O. shaft.

Helping leading farm equipment manufacturers achieve new, higher standards of performance is a specialty of Rockwell-Standard engineers. They are experienced in developing jointed drive shafts for both specialized and conventional farm equipment—involving everything from manual steering assemblies, to power take-off drives, to heavy-duty propeller shafts.

Perhaps you can also benefit from Rockwell-Standard engineering experience and facilities. For a prompt answer, just write, wire or phone. We'll help you build a better implement – with savings in time and money, too.

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R/M POLY-V® DRIVE...

New Reliability...

MORE POWER IN LESS SPACE FOR

NEW IH HAY CONDITIONER

International Harvester's new Hay Conditioner automatically gathers freshly cut hay, crushes it for quicker drying and earlier pick-up by a hay baler. To assure day in, day out dependability of the power driven unit, this IH Hay Conditioner is equipped with R/M's patented Poly-V Drive. Poly-V delivers *more* power in *less* space—with a degree of reliability not possible with multiple V-belt drives. The Poly-V belt acts as a safety clutch and prevents serious damage to the machine in the event the machine picks up something that jams it.

Let R/M engineers help you determine the best Poly-V installation for the farm equipment you design or manufacture. Write for Bulletin M141.

- **Poly-V employs a *single*, endless V-ribbed belt running on precisely mating sheaves.**
- **No matching—No belt turn over.**
- **Complete contact Pressure—Unique design gives the belt up to *twice* the traction surface of a comparable set of V-belts.**
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- **Poly-V maintains groove shape.**
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RM1001

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• MANHATTAN AGRICULTURAL V-BELTS • CONDOR WHIPCORD ENDLESS BELTS • R/M POLY-V® DRIVES

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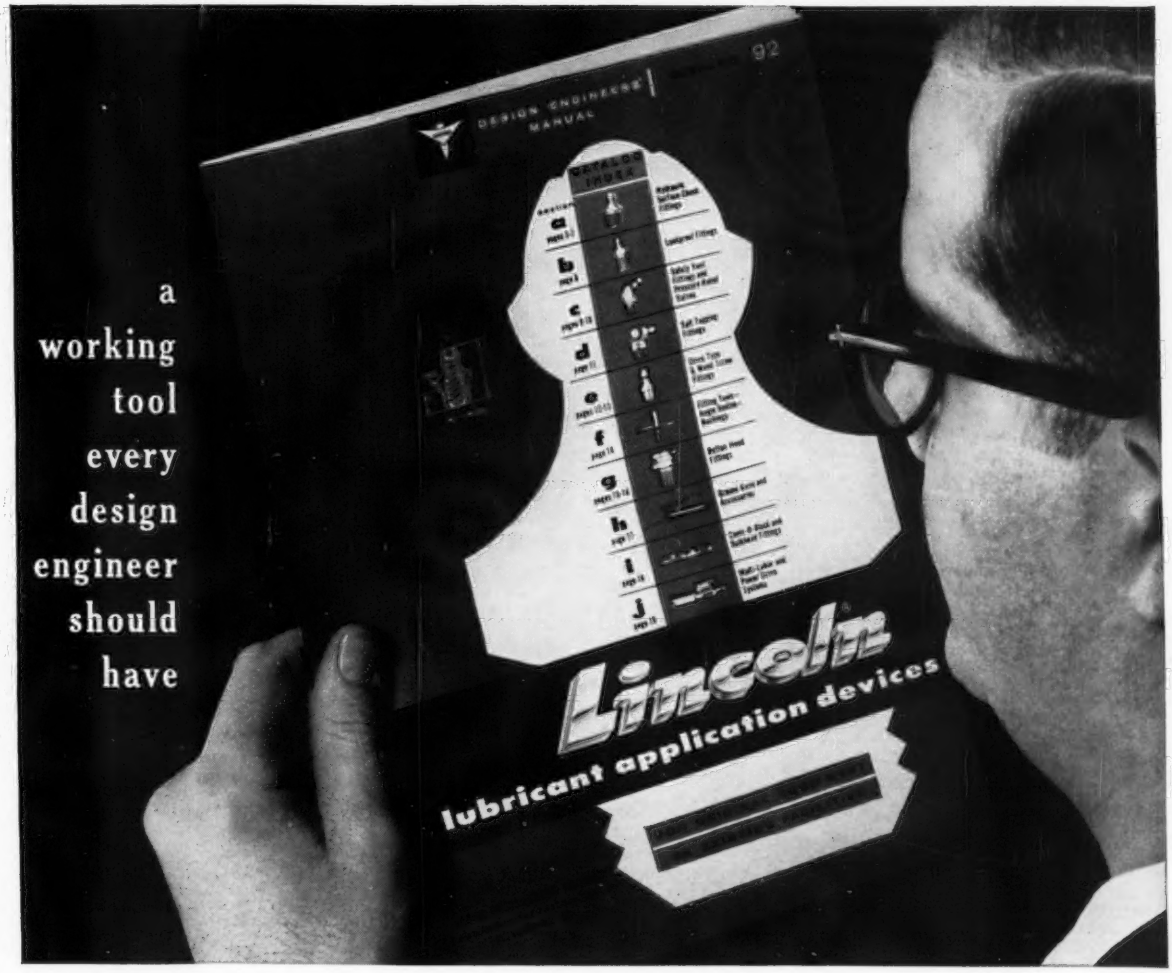
RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY

NEW! Design Engineer's Manual of *Lincoln* LUBRICANT APPLICATION DEVICES



Here is the most complete catalog of modern lubricating devices ever prepared for design engineers . . . Lincoln's new manual of lubricant application devices for original equipment or existing facilities. Includes detail, actual size drawings with complete specifications on each grease fitting and application device.

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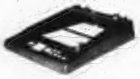

ELECTRONICS
Stamped radar base

CONSTRUCTION EQUIPMENT
Forged steering spindle

ROAD BUILDING
Forged track link

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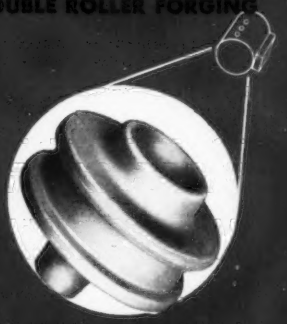

A critical 117-lb. forging (with 12" max. diameter), which required expert die design to control grain flow, for strength and toughness.

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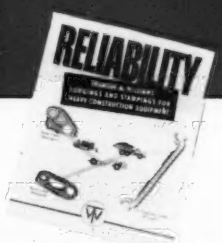

FORGINGS & DEEP DRAWN STAMPINGS

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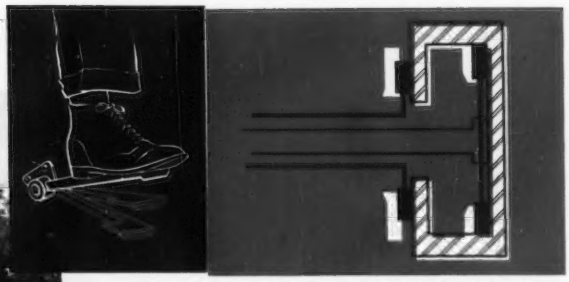
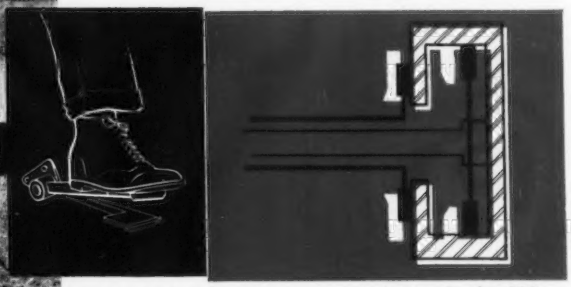
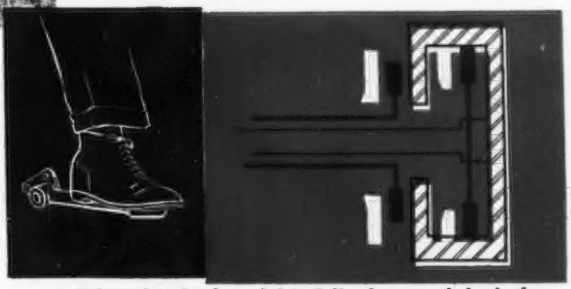


When the clutch pedal is not depressed, both the transmission and PTO clutches are engaged.



At the halfway mark (you can feel it) only the PTO clutch is engaged. The tractor stops.



When the clutch pedal is fully depressed, both the transmission and PTO drives are disengaged.

SPICER'S DUAL DRIVE TRACTOR CLUTCH . . .

Controls Both The Transmission And PTO With A Single Two-Stage Pedal

In the Spicer Dual Drive Clutch, both the transmission and the PTO drives are operated by a single two-stage foot pedal. This design leaves the operator's hands free at all times for safer steering, faster gear changes and precision implement adjustments.

For added efficiency, the tractor can be stopped while the PTO continues running . . . simply by depressing the clutch pedal to an easily recognized mid-point. This is a tremendous advantage to the farmer who is baling heavy windrows of hay, picking a high-yield stand of corn, or doing any number of tasks. For greatest safety, the tractor and PTO work may be instantly stopped by completely depressing the pedal.

Add to the safety and efficiency of your tractor design by incorporating a Spicer Dual Drive Clutch. The Dana engineers will be glad to help you with any clutch or transmission problem.

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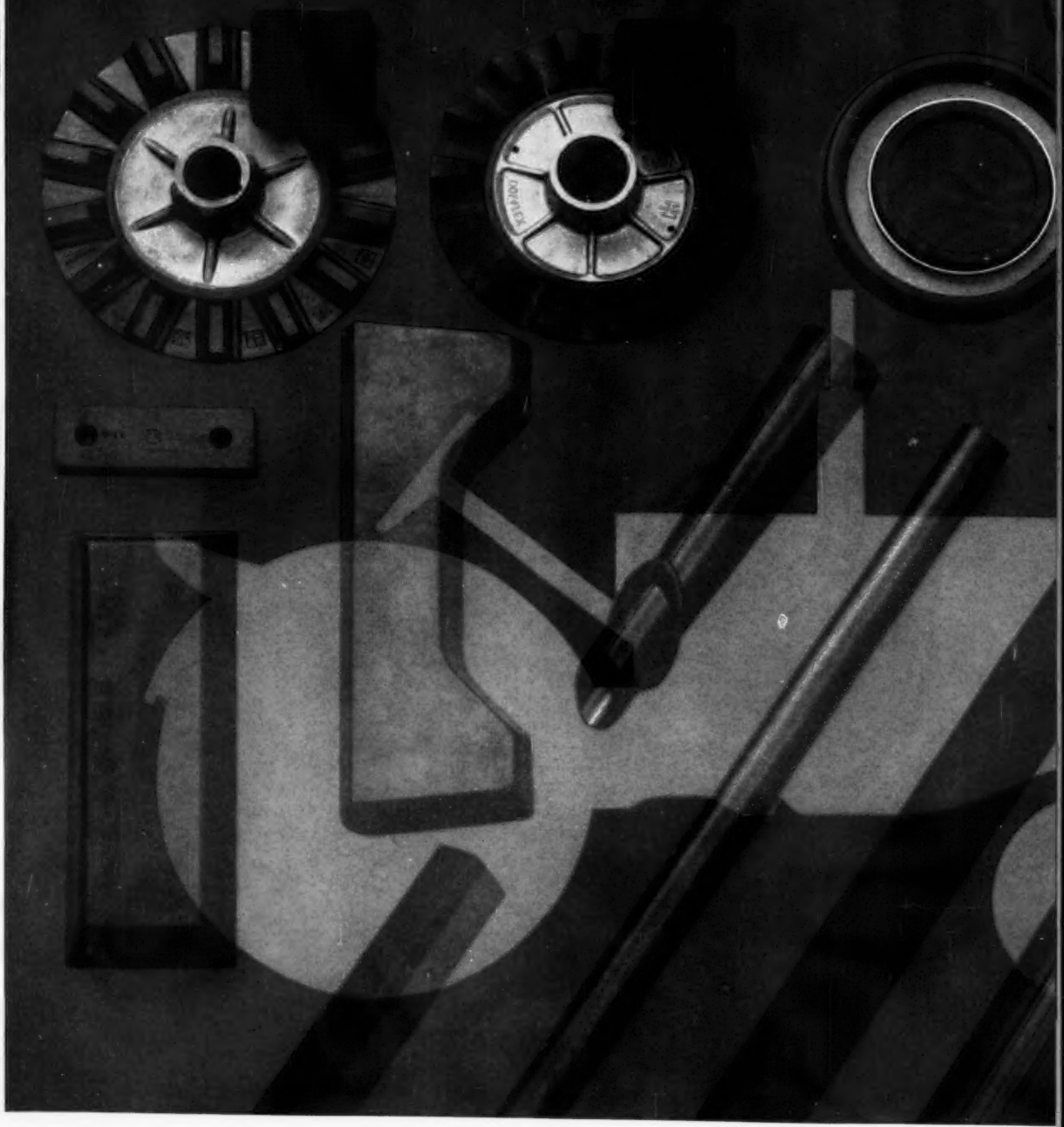
OHIO RUBBER

"CUSTOMEERED* COMPONENTS BASIC TO INDUSTRY"



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plant quality . . . reap value

OHIO RUBBER IS THE GOOD SOURCE FOR THE AGRICULTURAL IMPLEMENT MANUFACTURER!

THROUGHOUT THE ENTIRE FARMING CYCLE ORCO quality rubber components build-in extra performance, low maintenance for agricultural implements and machinery. From initial ground clearing to final harvest—ORCO IDEA PARTS enable brush clearers, gang plows, planters, cultivators, cotton pickers, hay balers, corn huskers and other agricultural implements to reach efficiency peaks planned by their manufacturers.

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ORCO CAPACITY guarantees your part to be made right—and on schedule! Integrated research and design facilities, electronically-controlled compound mixing, the modern facilities of four major plants assure uniformity, quality, delivery. Over 75 years of pioneering experience in custom-crafting OEM components of rubber, synthetic rubber, silicone rubber, polyurethane, or flexible vinyl define the Ohio Rubber Company as the industry standard of single source control and responsibility—of product excellence.

TIRES ARE IMPORTANT TOO!

ORCO's 16-page "Soil King" booklet (Form 429) tells the complete story on tires for agricultural service. Get your free copy of it as well as descriptive folder "ORCO Component CUSTOMEERING" (Form 715) on Ohio Rubber's complete facilities and services for forming rubber.

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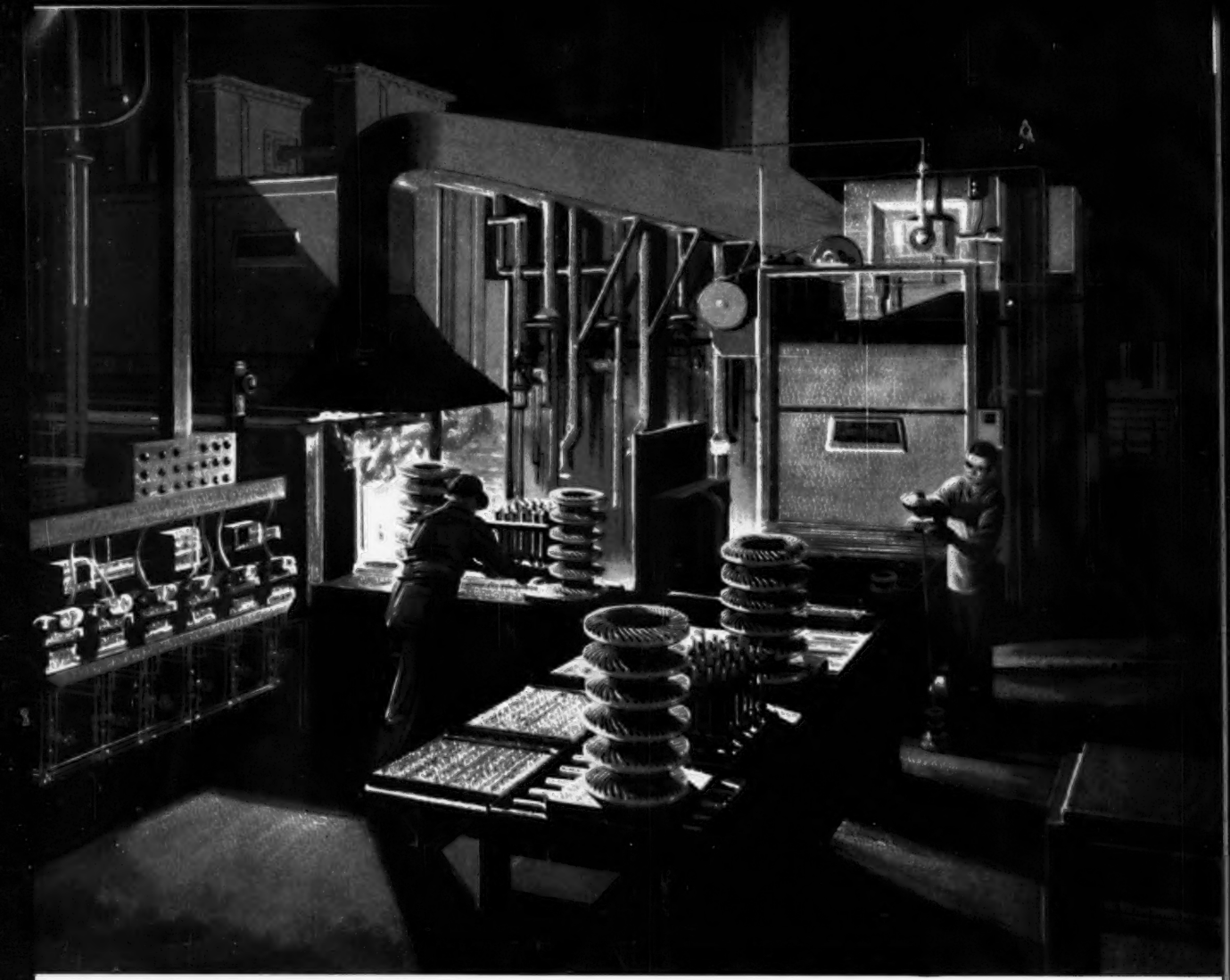

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This huge, continuous, carburizing, hardening and draw furnace now permits even greater instrument control in heat treating DOUBLE DIAMONDS for maximum wear resistance and load-carrying capacity. So far as we can discover no more efficient furnace could be installed to achieve the quality characteristics our gear customers have come to expect.

At your request, our gear engineers would be pleased to describe this process in greater detail and to explain, as well, what our recently expanded facilities can mean in terms of this pledge: "DOUBLE DIAMOND Gears offer the advantages of lower installed cost and economical and dependable service on the job . . . gears that do credit to your product and reputation."

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GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
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Solving difficult Bearing and Special Parts Problems–

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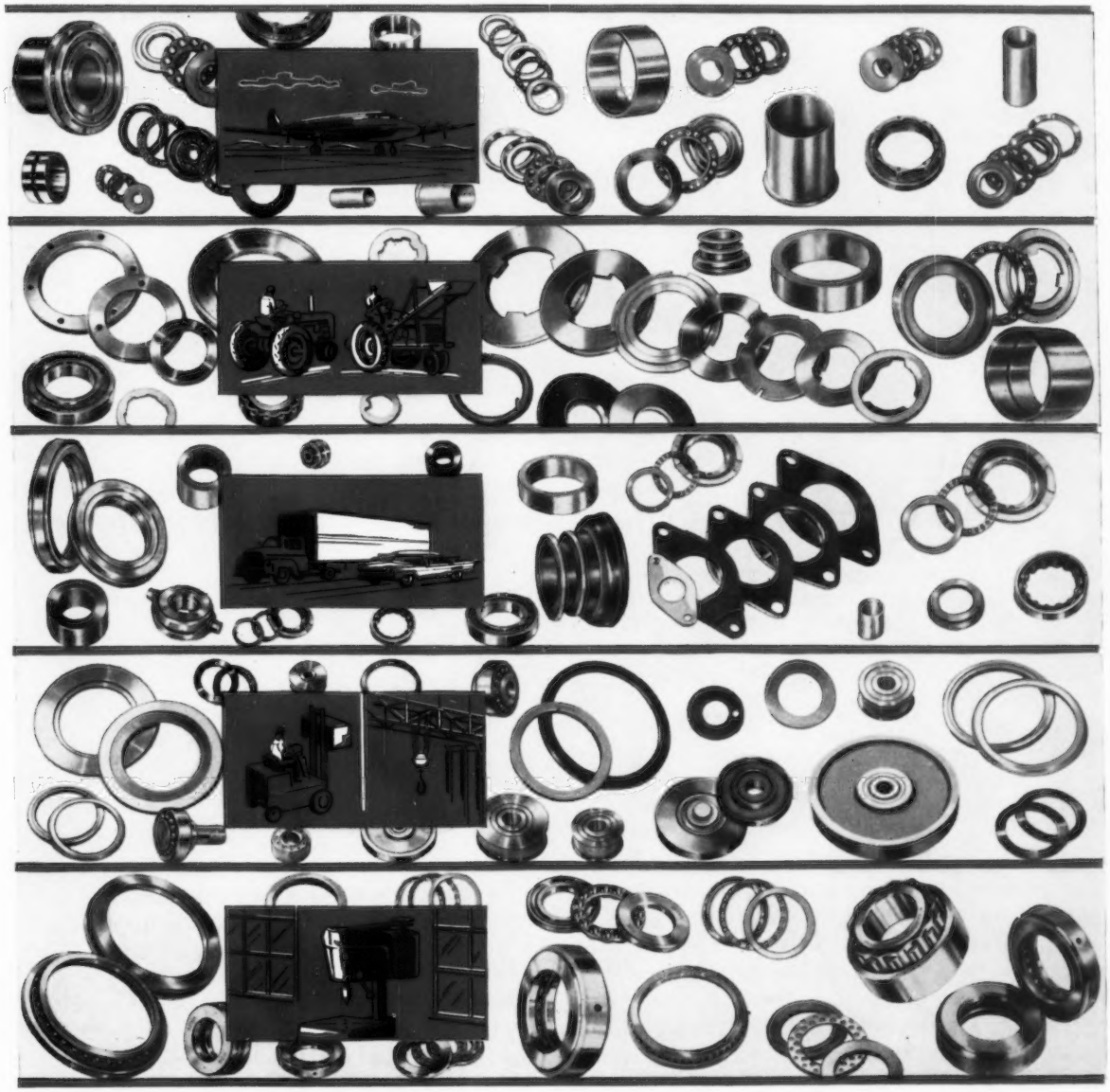
The challenge of new and unusual problems is of continuous interest to Aetna design and application engineers. Their readiness to accept the difficult has established Aetna as a leading source for specially engineered or hard-to-make bearings, and hardened and ground precision parts.

Whatever your problems may be, the Aetna engineering facilities for design and application are available to assist you. Why not outline your anti-friction or parts problems for Aetna study, consideration, and recommendations on how to best achieve operational efficiency and long life expectancy in your products.



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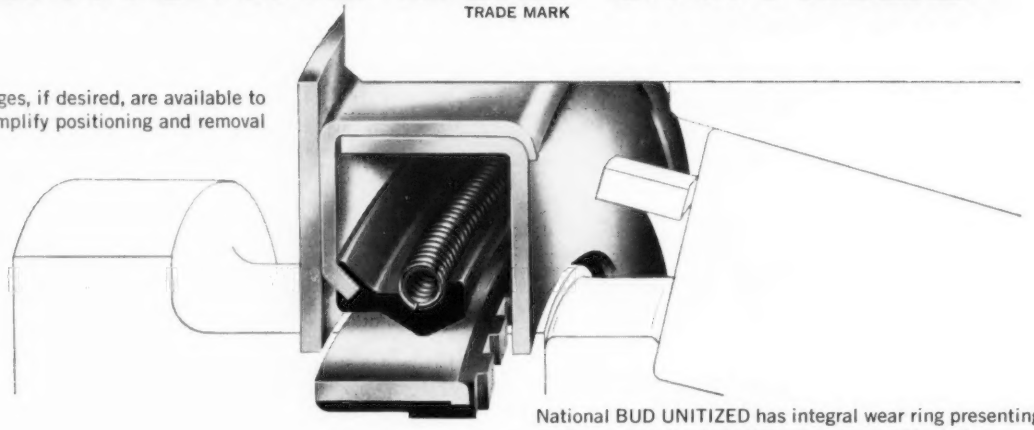
NATIONAL BUD UNITIZED

TRADE MARK

Flanges, if desired, are available to simplify positioning and removal



National BUD UNITIZED has integral wear ring presenting rubber surface to shaft. Wear ring turns with shaft, sealing lip is never exposed to damage, cannot score shaft.

A new unitized oil-seal-and-wear ring that eliminates:

SHAFT WEAR OR SCORING

SEPARATE METAL WEAR SLEEVES

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COSTLY SHAFT RE-MACHINING

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SPECIAL INSTALLATION PROCEDURES

New National BUD UNITIZED seals are now in production, in a limited range of sizes, for heavy oil and grease sealing applications — including truck, bus and tractor uses. Still newer BUD UNITIZED seals are on the way for higher speed automotive and similar uses.

Changing a National BUD UNITIZED oil seal automatically changes the wear sleeve — in one fast, simple operation. Since the seal has its own integral wear ring, it is almost impossible to install it other than squarely on the shaft. Expensive shaft finishing is no longer a necessity, nor is leakage under a metal wear ring a problem — both thanks to the rubber surface BUD UNITIZED presents to the shaft.

For complete details or skilled engineering help on application of BUD UNITIZED seals, write direct, or call your National Seal Applications Engineer. You'll find him in the Yellow Pages, under Oil Seals.

NATIONAL SEAL

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6013-R

Coolness... efficiency... NOW—attractive colors, too!

Alcoa® Rib Roofing, in natural aluminum finish, diamond embossed for attractive appearance, and warranted against corrosion, is recognized as an ideal material for both pole buildings and for beautifying the farmstead. And now, you may also obtain Alcoa Colorib* Panels in seven baked-on enamel colors.

Heat-reflective aluminum helps reduce costly milk and egg production slumps. Because aluminum reflects solar heat, buildings erected with Alcoa Rib Roofing remain up to 15 degrees cooler—even on the hottest summer days—keep livestock healthier and more productive. And, because it is light in weight and easy to apply, aluminum roofing saves on erection costs—as much as 75 per cent on pole-type farm buildings!

ALCOA STANDARD RIB ROOFING OFFERS ALL THESE MONEYSAVING ADVANTAGES:

- Ribbed configuration provides high strength, to withstand heavy snowfalls and high winds when used on pole-type buildings
- Diamond embossed for attractive appearance and reduced glare
- A 30-year warranty against corrosion damage
- Permanent freedom from painting
- Siphon drainage, to prevent wind-driven side seepage
- Available in lengths from 6 to 18 ft; width provides 4-ft coverage

Alcoa Colorib Panels (white, gray, light or dark green, blue, red and gold) also offer 4-ft coverage, come in 8-, 10- and 12-ft lengths. Both Alcoa Rib Roofing in natural aluminum finish and Alcoa Colorib Panels are extremely suitable for carports, patio shades, playroom panels and many other applications around the farm, in addition to barns and other buildings.

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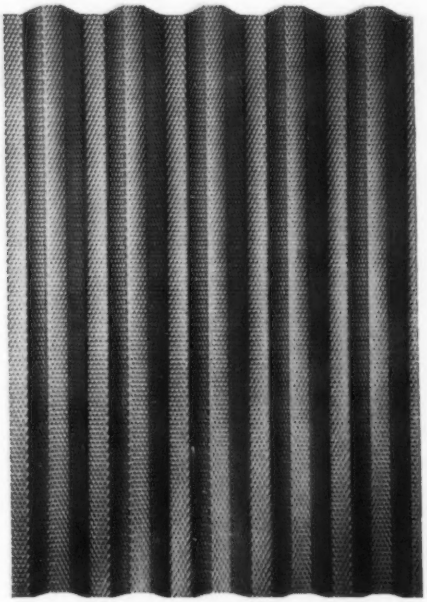
Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

ALCOA ALUMINUM



Let Alcoa answer your questions about how Alcoa Rib Roofing and other aluminum products can contribute to more efficient farming. For your convenience, use the coupon below to order informative booklets and leaflets for your files.

SEND FOR FREE LITERATURE TODAY

To aid you in your work with farmers, Alcoa provides a variety of information on farm applications of aluminum. Your requests for this material are welcome.

Agricultural Division, Aluminum Company of America, 1951 E Alcoa Building, Pittsburgh 19, Pa.

Please send items checked

☐ Alcoa Rib Roofing leaflet ☐ Alcoa 4-V Roofing leaflet ☐ One complete set of nine pole-building Steplans ☐ *Pole Barn Plans Catalog . . .* lists Alcoa plans available to farmers ☐ "Barn Raising, U.S.A.," 18-min sound-color film on pole-barn construction using aluminum roofing and siding† ☐ Alcoa Farm Gate literature . . . facts about aluminum gates.

†Films may be borrowed for public showing. Specify dates wanted.

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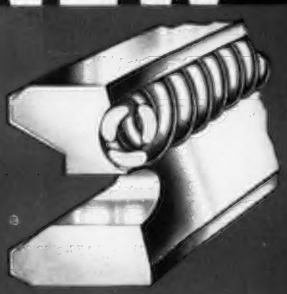
NEW



ACTUALLY 3 SPRINGS IN ONE!

As shown in this enlargement, the tri-coil spring is composed of 3 integrated coils. The spring's amazing strength and durability are the result of this triple-coil design.

HEAVY-DUTY OIL RING WITH

TRI-COIL OFFSET SPRING

solves tough oil control problems—
and only Perfect Circle has it!

Exclusive new Perfect Circle tri-coil spring has maximum area of contact with the ring all the way around—provides more uniform pressure than an ordinary hump-type expander. This results in higher cylinder conformability with less friction.

And, the stainless steel spring is offset in a channel next to the ring slots, rather than being directly behind them. Ventilation is greatly increased, and clogging of the ring and spring is reduced to a minimum.

Heat stability and easy installation are two more of the many more outstanding features of the new Perfect Circle OS 89. Get complete information from your Perfect Circle representative today!

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PISTON RINGS • PRECISION CASTINGS
POWER SERVICE PRODUCTS • SPEEDOSTAT

Hagerstown, Indiana — Don Mills, Ontario, Canada

Agricultural Engineering

May 1960
Number 5
Volume 41

James Basselman, *Editor*

LIFE SCIENCES AND ENGINEERING: Their Interrelationships

ANYONE who attempts to develop the topic of the interrelations between the life sciences and engineering is faced with a formidable task. This is not because relationships do not exist, but because of the very complexity of the biological sciences and the engineering sciences. This complexity forces us to segment our knowledge into branches, disciplines, or areas which we hope are manageable on our part. We then devote our efforts to understanding some small part of the whole. The very limitations of our intellectual capabilities force us to do this. Yet, occasionally, we should attempt to see and understand how our small part fits into the whole. When we are successful in this attempt to see interrelations, we become better scientists and engineers.

One should have no trouble in showing the interrelationships between the life sciences and engineering. Yet to document true relationships, rather than just areas of cooperation, turned out to be a difficult task. I am not sure you will agree that what I have to say demonstrates true relationships instead of areas in which cooperation is necessary and desirable.

It is perfectly logical that agricultural engineers should be concerned with and interested in the life sciences. Your sphere of activity is more closely intertwined with the life sciences than is that of the other branches of engineering. There can, of course, be some exceptions to this statement. But your relation with agriculture puts you in close day-to-day contact with the life sciences. It is, therefore, proper that you should have more than a passing interest in them.

It will be wise, at this point, to present some definitions so as to be on common ground. Remember that these are my definitions, and they are possibly riddled with inaccuracy. But, if you understand what I mean, I shall be satisfied. I think of the natural sciences as including two major parts — the life or biological sciences and the physical sciences. Each of these includes basic, or fundamental, knowledge and certain disciplines which apply these fundamentals.

There are several major applications of the life sciences, i.e., spheres of human effort devoted to the application of fundamental principles. Agricultural sciences, for the most part, are the application of the biological sciences to broad problems associated with the production of food and fiber and the conservation of certain natural resources. Please note that this is a limited description and in no way describes the complex agricultural industry of today. Agriculture is a great user of the biological sciences.

Engineering, for the most part, is the application of the physical sciences. I form this statement from a definition cited by by Dean Everitt (1959) in his article, entitled "New Tools for New Engineers." The definition was proposed by ECPD. It is: "Engineering is the profession in which a knowledge of mathematical and natural sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the progressive well-being of mankind." I am struck by the similarity of purpose of the engineer and the life scientist. Though I have no wish to usurp the engineer's definition of his profession, it is equally true that the agriculturist employs "the materials and forces of nature for the progressive well-being of mankind."

Perhaps at this point it might be well to attempt to develop what seems to be a basic relationship between the biological sciences and the engineering sciences. In both cases the starting point for these sciences is the basic structure of matter and the forces that are exerted on its fundamental components. I realize that this is an oversimplification, but it at least gives us the concept of a basic relationship. Specifically the fundamental subjects in the natural sciences to be mastered before a real understanding can be reached in either the biological or engineering sciences are chemistry and physics. Because of this common root, one can argue the point that a relationship between the biological and engineering sciences most certainly exists. I know that there are areas in each in which complete mastery of these fundamentals is not prerequisite to a successful career. For example, the plant taxonomist may be concerned only with recording the nature of plants as he observes it; therefore, he needs less of the fundamental sciences. On the other hand, if the plant taxonomist is concerned with the question of why a certain plant has a particular form, then he most certainly must be concerned with fundamentals. You can supply examples in engineering that will be comparable to my taxonomist.

At the risk of digressing here, I'd like to make a few brief comments about some differences between the physical and biological sciences. The physical sciences got a good start a long time ago, because it was possible to pull the physical world apart and to study these parts one by one. At the center of physical theories are a few general laws of great simplicity, generality, and power, and they have been rather accessible to man (Weaver, 1957). On the other hand, progress in biology has been somewhat slower. The biologist has to compete with living material, which is always to some degree unpredictable. A living organism is complicated, no matter how simple it is. Only a characteristic or two can be studied at a time. Even then, when the living organism is pulled apart, it is no longer an organism and no longer alive. It loses thus one of its essential characteristics, life, and it is no longer a proper subject for study of live processes. For further exploration of this general problem, I refer you to two papers in the March 8, 1957, issue of *Science*. One is entitled "Structure of Physical Science" (Zacharias, 1957) and the other is "Units and Concepts of Biology" (Gerard, 1957). Both of these deal with fundamental units and concepts.

To get back to the relationships of the biological and engineering sciences, let us accept the thesis that they have a common root. The structure of each is increased by adding that body of knowledge peculiar to each. On the one hand, we find anatomy, physiology, genetics, biochemistry, and a whole host of special subjects. On the other, we have materials, statics, geochemistry, dynamics, design, and a wide variety of other subjects, both basic and applied.

In spite of our classification of the sciences, there are a number of areas in which the biological and physical sciences have not separated completely. Let us take a few specific examples and see what interrelationships might exist.

Biochemistry is a science which deals with the chemistry of living organisms. It lies in the border area between the biological and physical sciences — between physiology and chemistry. Biochemistry uses the methods and theories of organic and physical chemistry in physiological problems. It is concerned with the activity of the thousands of chemical compounds found within a living organism. Although the chemical laws which apply to inanimate materials are equally valid within the living cell, the task of the biochemist is invariably more difficult than that of his counter-

(Continued on page 310)

An address before a meeting of the Southeast Section of the American Society of Agricultural Engineers at Birmingham, Ala., February 1960.

The author — WILSON B. BELL — is associate director, Agricultural Experiment Station, Virginia Polytechnic Institute, Blacksburg.

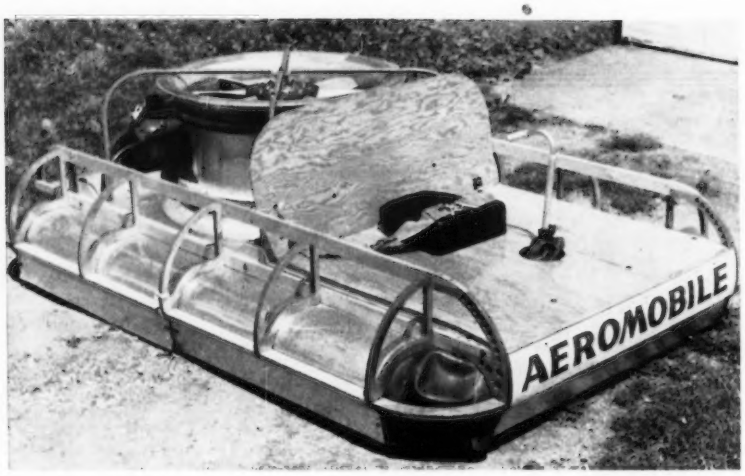

Fig. 1 An experimental model of the Aeromobile, a ground-effect vehicle

The Aeromobile: A Peripheral Jet Vehicle

William R. Bertelsen

THERE are now two categories of aircraft. The first comprises those which receive lift through inertia, momentum, or thrust. This includes all familiar aircraft: the fixed-wing airplane, the helicopter, the autogyro, the ducted-fan flying platform, the tail-sitting jet vertical take-off aircraft, etc. These machines accelerate downwards a sufficient mass of air per second to sustain their weight by reaction.

The second category includes craft which sustain themselves mainly by pressure created beneath. So far these are confined to flight a few feet off the surface and are ground-effect vehicles.

It is this newest category which promises to be of most immediate use to the general public for daily transportation and to certain users such as physicians, the military, farmers, ranchers, explorers, etc., for special purposes. The ground-effect machine is at once comparatively simple in construction and operation and quite versatile as an omnivagant craft of high speed and large load-carrying capacity.

Ground effect has been known since men began to fly. It was noted early that more lift was obtained near the ground, and some unsuccessful aircraft would fly near the ground but would not rise out of the ground-effect region. Little note was taken of this phenomenon until Toivo J. Kaario in Finland began experiments with small models about 1935 and later built a man-carrying machine which was only partially successful. He was unable to interest anyone in his machines and stopped active work.

Within the last six years, independent work on ground effect as a means to transportation began in England, France, Switzerland, Canada, and several places in the United States. Apparently all of those workers were unaware of each other and of Kaario's work.

Types of Ground-Effect Vehicles

Air-lubrication type. This is a method of greasing the passage of a vehicle over its road by releasing a small amount of high-pressure air through pads or shoes on the bottom of the vehicle.

Pressure-leakage or plenum-chamber type. In this type the base consists of an inverted pan into which a motor fan forces a large volume of air at low pressure. As the air leaks away at the periphery, the fan replaces it to maintain a low pressure to support the craft.

Peripheral-jet type. The base of a peripheral-jet machine is solid in the center and air driven by the motor fan exits from a continuous slit around the periphery. This forms a jet curtain of air which both builds and confines pressure under the center body of the machine.

Advantages of the Peripheral Jet Design

Higher altitude and greater weight lifting for a given power can be achieved by the peripheral jet machine because of the dynamic screen preserving pressure below.

Stability is greatest in the peripheral-jet machine since all reaction thrust produced is at the perimeter at the widest possible base. Greater center-of-gravity travel is tolerable over the single plenum chamber type.

Propulsion is inherent in the peripheral-jet design without additional power source or propulsion equipment if the machine is tilted in the direction of desired travel by varying the local thrust of the peripheral jet. Tilting is the method of propulsion used in the helicopter. A few degrees of tilt provides a strong propulsive force.

Control is inherent in the peripheral-jet machine by varying the magnitude and direction of the peripheral-jet exit locally. Pitch, roll, and yaw control and control of trim of eccentric loads is similar to fixed-wing aircraft or helicopters. The same control system will operate in and above the ground-effect region for low or high flight.

The peripheral-jet machine can be designed lower in silhouette, lighter in weight, more compact; it is simpler and least expensive since it needs only one fan, one engine, a ducting system, and flaps with remote control. This type of machine can be designed with an unobstructed deck with a single motor fan at one end. A dual fan is not necessary, and only one end of the vehicle needs to be occupied with the power system.

Principles of the Aeromobile*

The Aeromobile, a peripheral-jet vehicle, has three sources of lift. The principal lifting force is from pressure built beneath the base, which accounts for over 90 percent of the total lift. The other 10 percent is derived in part

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The author — WILLIAM R. BERTELSEN — is president of the Bertelsen Mfg. Co., Neponset, Ill.

*Aeromobile is a trade name and patents are applied for.

from reaction thrust of air accelerated downward and in part from a lowered air pressure above the craft and in particular at the rim of the duct inlet.

The pressure developed by the fan in the Aeromobile is on the order of 0.1 lb per square inch, and this is applied to the base of the machine via the peripheral jet. Since there is over 6000 sq in. of area, the total force is about 600 lb. If the base area were increased, both the altitude and the total lifting capacity would increase.

The character of the ground effect of the peripheral jet is that pressure and therefore lift rises inversely with the altitude. As the machine is forced closer to the ground by increasing its load, the lift rises to support that load. As a result, the ground-effect machine can lift enormous weight for a given horsepower. It equals or exceeds the efficiency of a fixed-wing aircraft which carries its load only at fast forward speed while the ground effect machine will hover and move at fast or slow speeds. It exceeds the helicopter in sheer weight lifting in hover or forward speed. The Aeromobile has lifted a total of 1340 lb just clear of the ground, and this is 18.6 lb per horsepower, even though it is a rather inefficient machine.

Propulsion

Once the machine and its load are lifted free and clear of the surface, however slightly, it can be moved without friction in any direction—forward, backward, sideways, pivotally, etc. Several means of propelling the ground-effect machine have been proposed including conventional air propellers, ducted fans, jet or rocket engines. Another system is to bleed air off the fan and use its reaction to propel and control the machine. Others have attempted to direct the air as emitted from the jet for propulsion and control.

It is the author's conclusion that, for small vehicles as contrasted to huge ocean-going machines, lift, propulsion, and control should be obtained from the same power source. Adding special propulsion equipment increases the weight and expense of the craft. Bleeding air from the fan reduces its total altitude and produces a low order of horizontal force. Directing the air from the jets to cause translating force is relatively ineffective. We found that no other method could equal the propulsive force produced by tilting the machine in the direction of desired travel.

It proved to be very important to have control of the tilt of the machine because a hovering machine will move in the direction of tilt. If the craft is heavy on one side, it tilts to the heavy side and inexorably moves off in that direction. With local thrust control on the peripheral jet, it is possible to trim out a certain amount of eccentric load. On a slope the Aeromobile moves downward unless tilted toward the uphill side.

In turning corners, it is useful to bank the craft and have the centrally directed horizontal component of the tilted main lift vector keep the machine from moving out tangentially.

In hill climbing, a machine which assumes the tilt of the hill has a strong downhill component of the tilted main lift vector which must be overcome before the hill can be climbed. If the machine is tilted opposite to the slope of the hill, it will climb on its own lift. In this situation, the main lift vector points uphill and the horizontal component is in the uphill direction. Operation on a sidehill becomes nearly an impossible situation for the machine in which tilt cannot be controlled. Enormous force is needed continuously merely to maintain the craft on the hillside, leaving little for propulsion. In addition the force holding the machine on the hill must act precisely through the center of gravity or the machine will rotate and become uncontrollable. No other system of producing horizontal force can be directed so efficiently in 360 deg around the base as tilting the machine.

Operation in crosswinds is also a problem to the ground-effect machine, but can be adequately countered by a slight down tilt into the wind.

Braking the Aeromobile is accomplished by reversing its thrust by tilting away from the direction of travel. It then rears up like a polo pony. With the low power and low efficiency of the experimental machine, the forces for acceleration are not large. For emergency stops, the Aeromobile is throttled down and skids like a car with locked wheels.

Steering or yaw control is achieved by differential deflection of the side flaps to produce torque around the center of gravity.

Agricultural Uses of Ground-Effect Phenomenon

If development of the principle goes no further than to provide all-weather transportation for rural people, it will have accomplished a great deal. The Aeromobile will do some things now impossible to land vehicles, but it will also make ordinary errands much faster and pleasanter. A road may be passable to an automobile, but deep mud makes it uncertain, dangerous and slow. The Aeromobile is unaffected by the nature of the surface that lies below it as it skims along at cruising speed. That means it will traverse roads, snow, swamp, water, ice, sand or soft ground with equal speed and ease.

The ground-effect machine opens up possibilities for the agricultural engineer to develop means for transporting heavy loads over unprepared ground, such as grain, fertilizer, water, cattle, men or machinery, either mounted or in transport.

Accessibility of fields and crops is another advantage. One could pass over growing crops as harmlessly as the wind. This might allow the farmer to dust, spray, or tend crops while hovering safely above them. For example, the rice grower could travel over his flooded fields to repair dikes.

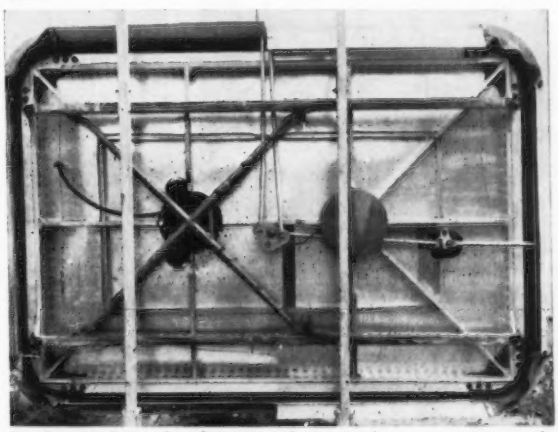


Fig. 2 Air driven by the motor fan exits from a continuous slit around the periphery. This forms a jet curtain of air which both builds and confines pressure under the center body of the machine

. . . The Aeromobile

There is an area of corollary use of the proximity effect in materials handling, lubrication, etc. We are studying the use of air as a lubricant for the share and moldboard of the plow and find this has some rather exciting possibilities for reducing draft and assuring scouring under all conditions.

Needless to say, there remain problems to be solved in the use of ground-effect vehicles, but enough experience has now been gained with these machines to know that their utility may be tremendous and that design and production of completely practical machines may not be too far in the future.

Ground Effect References

Aerodynamic theory of the annular jet, Part 1, Aerophysics Co., 17 Du Pont Circle, N.W., Washington, D.C. December 1958.

Boehler, Gabriel D., Remarks on the ground effect machine, American Helicopter Society Fifth Annual Western Forum, 2 East 64th St., New York 21, N. Y. September 25-26, 1958.

Boehler, Gabriel D., Aerodynamic theory of the annular jet, Paper No. 59-77, Institute of Aeronautical Sciences, 2 East 64th St., New York 21, N. Y.

Butz, J. S., Designers study air cushion vehicles, *Aviation Week*, p. 74, January 12, 1959.

Chaplin, Harvey R., Effect of jet mixing on the annular jet, Aero Report 953, Navy Dept., David Taylor Model Basin, Washington, D.C.

Chaplin, Harvey, and Stephenson, Bertrand, Preliminary study of the hovering performance of annular jet vehicles in proximity to the ground, Aero Report 947, Navy Dept., David Taylor Model Basin Aerodynamics Laboratory, Washington, D.C. August 1958.

Chaplin, H. R., Theory of the annular nozzle in proximity to the ground, Aero Report 923, Navy Dept., David Taylor Model Basin Aerodynamics Laboratory, Washington, D.C.

Locomoting on a bubble of air, *Business Week*, p. 34, August 1, 1959.

Mann, Martin, Here come cars without wheels, *Popular Science Monthly*, p. 51, July 1959.

Matthews, G. B., and Wosser, J. L., Ground proximity: A critical review, Paper No. 59-121, Institute of the Aeronautical Sciences, 2 East 64th St., New York 21, N. Y.

Rethorst, Scott, and Royce, W. W., Lifting systems for VTOL vehicles, Report No. 59-123, Institute of the Aeronautical Sciences, 2 East 64th St., New York 21, N. Y.

Symposium on ground effect phenomena, Princeton University, Princeton, N. J., October 21-23, 1959.

Tinajero, Anibal Alfredo, Comparison of experimental and theoretical design parameters of a 6-inch diameter annular jet model with a jet angle of —45 degrees hovering in proximity to the ground; and experimental results for forward flight at zero angle of attack, Aero Report 954, Navy Dept., David Taylor Model Basin, Washington 7, D.C.

The ground cusion phenomenon, Hearings before the Committee on Science and Astronautics, House of Representatives, Eighty-Sixth Congress, House Office Bldg., Washington, D.C. April 13-15, 1959.

Von Glahn, Uwe H., Exploratory study of ground proximity effects on thrust of annular and circular nozzles, National Advisory Committee on Aeronautics, Technical Note 3982, NASA, Washington, D.C. April 1957.

Specifications

General:	Height 32 in. Width 71 in. Length 101 in. Empty weight 410 lb Gross weight 585 lb
Engine:	McCulloch 0-100-1, 72 hp, 2 cycle, 4 cylinder, 4000 rpm Fuel consumption 5 gph
Fan:	30-in. diameter, 8 blade, aluminum, 10-deg twist, adjustable pitch, 10-in. hub diameter, 11-in. starter ring gear
Performance:	Maximum altitude at 585 lb gross weight—6 in. Maximum attained forward speed — 40 mph Operating terrain — any unobstructed surface without steep grade or projections higher than the operating altitude. It travels over snow, ice, open water and ice, paved roads, plowed ground, marsh land, etc. Grade climbing — maximum of 6 percent at gross weight
Construction:	Aluminum sheet, marine plywood, spruce wood, steel tubing
Control:	Moveable aluminum flaps surround the base and control the angle of the peripheral jet discharge and the local volume of the jet. By control of the thrust at the periphery, powerful forces in pitch, roll, and yaw moments can be produced
Propulsion:	By tilting the machine in the desired direction of travel by means of the control flaps operated remotely from the control stick, the horizontal component of the main lift vector propels the machine forward, sideways and backwards. Pivot turns and yaw control are produced by differential deflection of the front and rear sections of the side flaps

STUDENT BRANCH STAGES OUTSTANDING EXHIBIT

Fuel cell tractor *(above)* and Aeromobile *(right)* were among displays shown at Illinois Student Branch exhibit during Engineering open house

AN estimated 10,000 persons visited the Illinois Student Branch exhibits displayed during the Engineering Open House, sponsored by the College of Engineering of the University of Illinois, on March 11 and 12. Outstanding displays of recent developments in the agricultural engineering field attracted much attention among the spectators. The exhibits included the new experimental fuel cell tractor, built by Allis-Chalmers Mfg. Co., an Aeromobile, built by Dr. W. R. Bertelsen, Neponset, Ill. (see article on page 290 of this issue), irrigation demonstrations, automatic feed handling models, a portable water channel to show flow patterns around various types of field tile inlets and dam overflows, models showing rural applications of electricity, and a model showing uses of steel in farm structures.

Thermoelectric Cooling and Power Generation

C. S. Duncan

State of development and application of thermoelectric devices

THERMOELECTRICITY has recently become a subject of intense research and development in many laboratories. The reason for this surge of interest is well founded. Recent increases in the efficiency of thermoelectric devices have enabled them to approach the point of competition with many conventional devices. In certain specialized applications, thermoelectric and conventional devices are already in direct competition. This situation exists in the realm of both refrigeration and electric power generation. Because the efficiency of thermoelectric devices is continuing to improve, the area of competition will doubtless grow larger.

In the year 1822, Seebeck, a German, discovered that an electric current will flow in a closed circuit comprising two unlike metals provided the junctions of these two metals are at different temperatures. In addition, he observed that the magnitude of the current was related to the magnitude of the temperature difference. Later, in 1834, Peltier, a French experimenter, discovered the opposite effect: a current in such a circuit would produce a difference in temperature between the two junctions. Four years later, in 1838, Lenz, a Russian, succeeded in freezing water at one junction in a circuit of this nature.

The possibilities of thermoelectric power generation lay idle for more than a century until, in 1937, a development program was begun in the Westinghouse Research Laboratories. This effort achieved measured efficiencies of about seven percent, but with the advent of World War II the project was curtailed in favor of more urgent things. Several years later, following the war, the program was resumed.

It is perhaps fortunate that efforts to develop thermoelectric power generation were essentially nonexistent for so many years. Certainly, in Seebeck's time, the necessary basic information was not available that a successful development program could be carried out. The atomic structure of matter and the existence and nature of the electron were not elucidated until the late nineteenth century. Further, the interpretation of what was observed would have been difficult because the evolution of solid state physics has been primarily within the past fifteen years. Fig. 1 historically relates important thermoelectric discoveries.

Paper presented at the Winter Meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1959, on a program arranged by the Electric Power and Processing Division.

The author — C. S. DUNCAN — is research engineer, Westinghouse Research Laboratories.

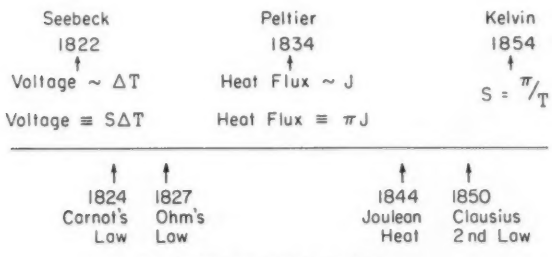


Fig. 1 History of thermoelectricity

Principles of Thermoelectricity

Thermoelectricity can more easily be compared with conventional methods of refrigeration and power generation if one has a basic understanding of the principles of thermoelectric-device operation. Fig. 2 represents a typical solid

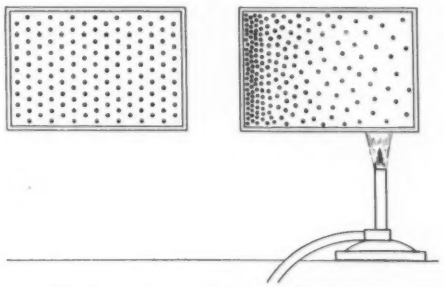


Fig. 2 Electron model of Seebeck effect

containing free electrons which can be made to move by the application of an electric field or by the application of a thermal field. When heat is applied to one side of the solid, the electrons will tend to become somewhat less dense in the warmer region and somewhat more dense in the cooler region. This condition is shown in Fig. 3, namely,

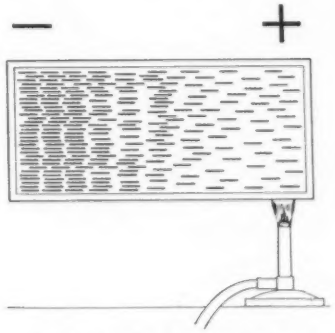


Fig. 3 Resulting electrical charge

an electric gradient. In order that this electrical gradient may be utilized to deliver electric power, a completed circuit is required. Such a circuit could be obtained simply by connecting externally the hot and cold ends of the specimen in this figure.

. . . Thermoelectric Cooling

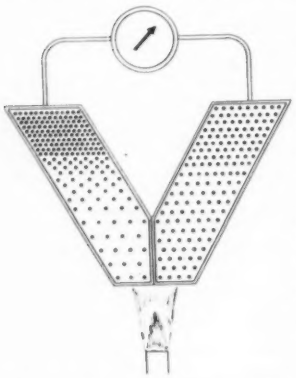


Fig. 4 Electron model of complete thermocouple

A more practical device requires the use of two types of thermoelectric materials as shown in Fig. 4. The explanation of this device involves use of the hole concept wherein the current carriers in one are positively charged holes, while those of the other arm are electrons as was previously mentioned. We then have P and N type materials to comprise a basic couple which makes the most efficient mode of construction for thermoelectric generators or refrigerators.

Three parameters determine thermoelectric material efficiency: S, Seebeck coefficient (microvolts per degree of temperature difference); σ, electrical conductivity, and k, thermal conductivity. These are combined into an expression which is an approximate measure of electrical generating efficiency,

$$M_W = T\,S^2\sigma/4\,k$$

in which T represents the absolute temperature. Fig. 5 illustrates the dependence of S and σ on the number of conduction electrons in a material. The thermal conductivity is not strongly dependent on the number of conduction electrons, and the optimum product of S^2 and σ is seen to be at an electron density of approximately 10^{19}. This density is represented by semiconductors or by other materials "doped" into that range.

Thermoelectric Device Considerations

Since the thermoelectric generator is another type of heat engine, the same basic expression of efficiency applies as with the steam-powered electric generator. That is,

$$\varepsilon_{\text{over-all thermal}} = \varepsilon_{\text{cycle}} \times \varepsilon_{\text{generator}}$$

In the case of the steam turbine generator, the cycle efficiency relates to the turbine, boiler, heat exchanger, etc., combination, and the generator efficiency relates to the generator and its losses resulting from such sources as windage, resistance, magnetic, friction etc.

Thermoelectric generator material serves as its own heat exchanger, since the highest acceptable temperature is applied to the hot junction and the heat which is not converted to electricity is discharged at the cold junction. Just as stages of a turbine are operated in series to obtain higher cycle efficiency so are thermoelectric materials or generators operated in stages. Since the only moving parts are charged elementary particles, the thermoelectric material resistivity previously discussed might be considered analogous to friction and windage of conventional generators.

Some of today's more efficient power plants operate with a thermal efficiency of around 40 percent, comprising about 45 percent cycle efficiency and over 95 percent generator efficiency. In thermoelectric generators much higher temperatures can be tolerated, thus providing cycle efficiencies of 70 percent or higher. As for generator efficiency, as high as 40 percent is a reasonable forecast. Thus the thermodynamic-cycle efficiency is the more desirable feature of a thermoelectric generator, and the electrical generator efficiency is the more desirable feature of a turbogenerator.

Present State of Devices

In several Westinghouse laboratories, and in other commercial and government laboratories, generators have been built in the range 1 to 100 watts output. Construction is now under way on several units extending into the kilowatt range. The efficiencies of these various generators range from as low as a few tenths of one percent all the way up to 10 or 12 percent. The calculated efficiency, based upon materials now at hand in the laboratory, is of the order of 15 percent. These materials are, as rapidly as possible, being reduced to actual generators.

The same solid state physicists who brought about this renaissance in thermoelectricity forecast that the efficiency of thermoelectric generators in the next ten or fifteen years is unlikely to exceed a practical limit of about 35 percent. Supporting this forecast is a vast and growing body of theory which is being applied successfully to the design of

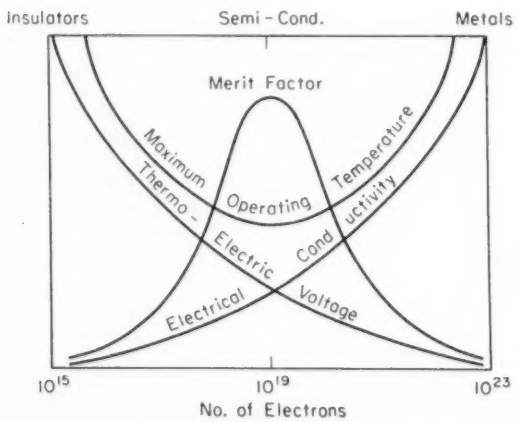


Fig. 5 Effect of electron concentration of thermoelectric parameters

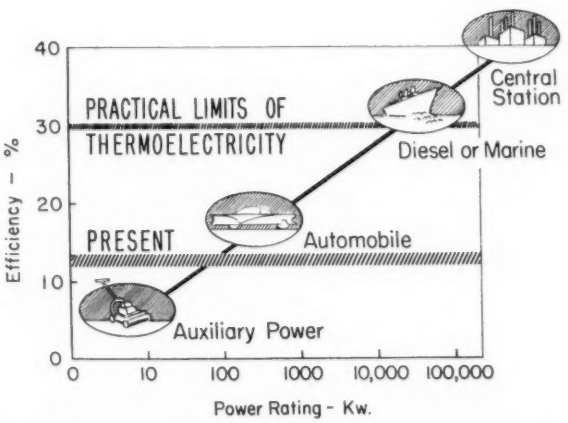


Fig. 6 Efficiency vs. power for typical rotating machines compared with thermoelectricity

thermoelectric materials. This same knowledge is, however, also being applied to the composition of turbine and electric-generator construction materials thus making it reasonable to expect continuing improvements in the efficiency of turbo-generators. It appears that an efficiency gap of perhaps 10 percent will always exist between the two methods of generation. Choice of generation equipment will then require a management decision to be based on the usual optimum of heat rate, capital cost, and maintenance.

The thermoelectric generator is an inherently low-voltage, high-amperage, direct-current source. In load applications requiring alternating current, inversion and transforming will be necessary. Inversion appears to be no obstacle. Not only are compatible new static inverters in an advanced state of development but conventional types of inverters can easily be applied.

Experimental thermoelectric refrigerators have been made in a variety of sizes and types ranging from tiny transistor coolers to full-size home refrigerators. Akin to thermoelectric generators, these devices inherently require low-voltage, high-amperage direct-current power. Thus in many applications transformation and rectification will be required. Thermoelectric refrigerators, as is also the case with generators, are being continuously improved in efficiency. Thermoelectric refrigerators are, at the present stage of development, generally somewhat less efficient than conventional types. But even with the present efficiency, they can do certain refrigeration jobs that either cannot be done at all or cannot be done as efficiently by conventional units. There is no inherent limit to the size that a thermoelectric refrigerator can be made. This applies to small sizes as well, and it is in this region of small size that it completely surpasses all competitors.

Future Expectations

Fig. 6 represents a convenient way of evaluating the competition for various generation tasks. The various categories of power requirements are shown and the relative position of thermoelectric generation, both present and future, is indicated. Three factors govern the slope of the curve: economy, convenience, and geometry. The only exact factor is geometry and it is related to the fact that the surface area to volume ratio increases with decreasing size. The other two factors are empirical. With thermoelectric generation, heat leak is the only mechanism for power generation. The factor of geometry which reduces efficiency in conventional heat engines is not effective with this new type of generation.

All of the area above the conventional power curve, but below the present or limiting thermoelectric curve, can be said to favor thermoelectric generation. Areas common to both means of power generation should be decided on the basis of first cost alone.

In the absence of moving parts, thermoelectric generators can doubtless be built at lower cost than conventional generators. In many instances lower capital cost will be a more important factor than heat rate. An example would be in cases of short-time or intermittent use as for peaking or emergency conditions.

Thermoelectric refrigerators are in a similar state of development as thermoelectric generators. As development progresses, the refrigerator will move further into a position of general competition and will doubtless further secure its position in the specialty realm.

Conclusion

Thermoelectric generators and refrigerators are now entering the commercial scene. It is the intent of this paper to introduce these devices to agricultural engineers that they may be better able to judge the proper time to employ them in their respective fields of application.

Acknowledgment:

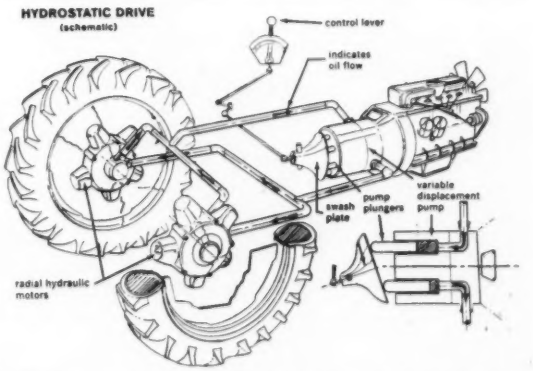
The author is indebted to Dr. J. C. R. Kelly for his suggestions in the preparation of this paper.

Evolution in Transmissions

A TRACTOR minus clutch and brake pedals and gear shift lever, and even without a rear axle, has been developed by International Harvester Company's Engineering Research group. Also missing in the new tractor is the big, hollow, main frame casting that houses transmission and differential in conventional tractors, and the entire complex of gears, shafts and splines that have always been needed to send power from engine to driving wheels. Despite such scarcity of parts, the tractor reportedly runs. In fact once the engine is started, a single lever on a quadrant near the steering wheel controls forward or reverse motion over an infinitely variable speed range without clutch and without gears to shift.

This research system, known as hydrostatic drive, has three major parts: a pair of radial, hydraulic motors — one in each driving wheel — and a variable displacement pump which furnishes pressure energy to the system. The pump is coupled directly to the tractor engine. Piston action in the motors resembles that of a radial aircraft engine, with oil pressure, replacing combustion and expansion of gases, to move the pistons. The pistons act on an eccentric which serves as a crankshaft, converting hydraulic pressure to torque.

Key to the system is the variable displacement pump in which the slightest plunger stroke is instantly converted by the motors to torque at the driving wheels. By changing the angle of a swashplate in the pump, the control lever can lengthen or shorten the stroke of nine plungers, thus increasing or decreasing speed of the tractor within its maximum range of about 11 mph.



It is the opinion of the company that study of the new transmission, to date, has revealed attractive performance characteristics, but at the same time poses problems (such as fuel economy and reduction of component costs) which will have to be solved before it can meet the competition of conventional gear drives. Further details may be obtained by writing to International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill.

Silo Storage of High-Moisture Shelled Corn

E. L. Hansen
Member ASAE

Research results show feeding value of high-moisture corn equal to dry corn

THE practice of storing high-moisture shelled corn in conventional silos has many obvious advantages such as early and rapid harvesting, a minimum of operations and equipment, lower cost and rodent-free storage, and simplified mechanical feeding.

The practice has been accepted by many without knowing too much about the best moisture content for harvesting and storing, feeding value, loss in storage, and nutrient yields per acre. This paper reports results of cooperative work at the University of Illinois involving agricultural engineering, dairy science and animal science departments.

One hundred-twenty acres of the same variety of corn were harvested as shelled corn and placed in conventional concrete stave silos at 35, 30, and 25 percent kernel moisture content. Some was harvested at 18 percent and dried to 13.5 percent for use as control corn in feeding trials. The effect of moisture content was studied on field losses, losses in storage, volume of grain, and in feeding trials of swine, beef, dairy heifers, milk cows and lambs in metabolism crates. The top of the corn in the silo was sealed with black polyethylene by digging a trench around the edge and forcing the film down and out against the silo wall. Edges of doors were sealed by extending polyethylene past the edges of the doors about four inches.

Paper presented at the Annual Meeting of the American Society of Agricultural Engineers at Ithaca, N.Y., June 1959, on a program arranged by the Farm Structures Division.

The author — E. L. HANSEN — is professor of agricultural engineering, University of Illinois, Urbana.

Author's Note: The results reported in this paper were obtained by the author in collaboration with U. S. Garrigus, professor of animal science; J. H. Ramser, assistant professor of agricultural engineering; K. E. Harshbarger, assistant professor of dairy science; and G. E. Mitchell, Jr. and A. H. Jensen, assistant professors of animal science; all are on the staff at the University of Illinois.

Fig. 1 Conventional silos offer convenient storage for high-moisture shelled corn directly after harvest

Harvesting

Corn was harvested with a self-propelled combine with corn head attachment. At 38 percent moisture the machine was operated one speed lower than when the moisture was at 35 percent or less. Heavy silks plugged the sieves at 38 percent and considerable corn remained on the cob. At 35 percent and below little difficulty was experienced.

Losses

Field loss tests made for each moisture level are summarized in Table 1. It should be noted that losses were lowest at about 30 percent kernel moisture.

TABLE 1. COMBINE LOSSES IN BUSHELS PER ACRE

	Percent kernel moisture			
	35	30	25	18
Ear loss (machine and detached)	0.8	0.8	2.7	5.4
Shelled loss (snapping rolls and separation)	2.6	1.6	2.3	2.1
Cylinder loss (on cobs)	5.2	2.4	2.4	0.4
Total loss in bushels per acre	8.6	4.8	7.4	7.9

Due to late planting and water damage the yield of this corn was between 40 and 50 bu per acre.

Influence of Storage on Chemical Analysis

Several samples of corn were taken for analysis as each silo was filled. Similar weighed samples in cheesecloth bags were placed in the silos. These samples were removed and analyzed as the corn was fed. Nutrient changes during storage were estimated from a comparison of these analyses and are presented in Table 2. Losses of dry matter, gross energy, and crude protein were not excessive.

TABLE 2. NUTRIENT LOSS (PERCENT) DURING STORAGE

Moisture content at harvest, percent	25	30	35
Moisture content when fed, percent	24	29	36
Dry matter	—2.16	—3.40	—1.19
Gross energy	—2.10	—4.83	—1.48
Crude protein	—1.31	—3.96	—0.33

Volume of High-Moisture Shelled Corn

High-moisture corn occupies more space per bushel than No. 2 corn. Weights and volume checks showed that the cubic feet per bushel for 25 percent moisture corn is 1.30, for 30 percent corn, 1.41, and for 33.5 percent moisture corn, 1.48, as compared to 1.25 for No. 2 corn. This means that, for corn at 30 percent moisture, the capacity of a given structure would be approximately 11 percent less than for No. 2 corn.

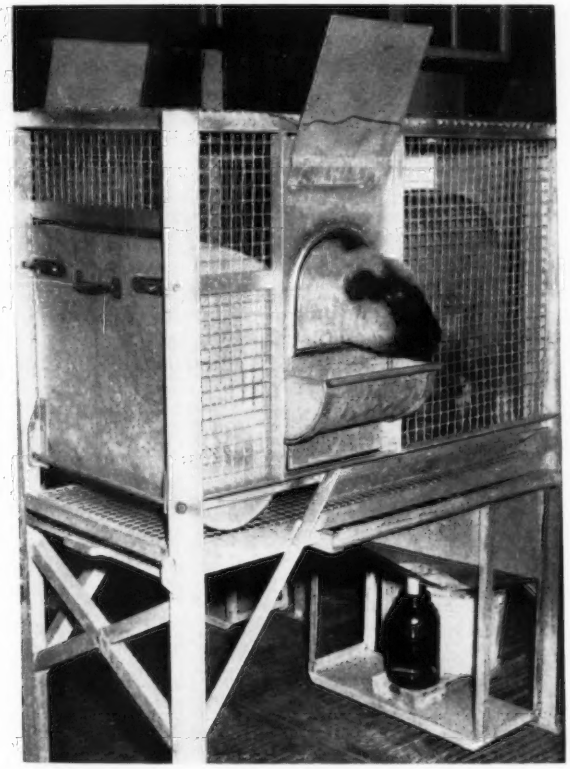


Fig. 2 In a metabolism crate feces and urine from lamb are collected. A chemical analysis of intake and output makes it possible to calculate the utilization of nutrients

Unloading Silos

Top unloaders were used in each silo. These did not operate entirely satisfactorily. Some changes were necessary on the drivewheels to obtain traction. Also, more corn was loosened than was removed which may have resulted in more rapid top spoilage.

Removing one inch of corn per day did not keep ahead of top spoilage. Three to four inches a day seems desirable in warm weather.

Feeding Value Comparisons for Lambs

Interest in the feeding value of ensiled high-moisture corn has been considerable. The purpose of this metabolism study with lambs was to measure the apparent digestibility of dry matter, energy, and nitrogen and also the apparent utilization of digested nitrogen (protein).

The corns tested were as follows: *(a)* field dried, ensiled at approximately *(b)* 25, *(c)* 30, *(d)* 35 percent moisture and dried at *(e)* 140 F and at *(f)* 220 F. The first four corns, *(a, b, c* and *d)* were from the same field. The last two corns *(e* and *f)* were comparable to each other except for the variable of drying temperature.

A standard metabolism trial (involving analysis of feed intake and of fecal and urinary excretions over a 6-day collection period following a 14-day adjustment period) was conducted using 72 grade lambs each randomly assigned to one of the six rations tested. These lambs were tested in four groups with eighteen lambs in each group. The rations used were as follows:

*Experimental corn** (equal fed, twice daily) approximately 2 lb. per day.

Roughage-supplement mixture (equal fed, twice daily) 1.4 lb.

	Parts
Dehydrated corncobs	32
Alfalfa meal	5
Molasses	4
Soybean oil meal	5
Complete mineral†	4
Aureomycin	10 mg. per pound of supplement
Vitamin A & D concentrate‡	1.0 gm per pound of supplement

*Different corns were fed at the same level based on the dry matter content of the field-dried corn.
†As shown in the *Journal of Animal Science* 17 (1958) 299.
‡5000 units A and 500 units D_2 per gram.

Table 3 shows the average apparently digested dry matter, energy, and nitrogen and the apparent utilization of apparently digested nitrogen. Nitrogen balances averaged about 7 grams per day indicating the lambs were being fed so that they grew rapidly.

TABLE 3. APPARENT DIGESTIBILITY OF DRY MATTER, ENERGY, NITROGEN AND APPARENT UTILIZATION OF NITROGEN IN GROWING-FATTENING LAMBS

Treatment	Type of corn	Number of lambs	Apparently Digested (Percent) Dry matter	Energy	Nitrogen	Nitrogen retained
1	14.5*	12	63.3	64.4	54.7	70.0
2	21.6*	12	64.8	64.6	58.1	71.7
3	31.6*	12	66.1	64.4	55.7	71.1
4	34.4*	12	65.7	64.9	58.4	66.3
5	140 F	12	66.8	66.1	57.7	68.8
6	220 F	12	66.5	65.9	58.6	70.3

*Percent moisture content as corn was fed.

The individual values were statistically analyzed by analysis of variance, and no significant differences between treatments were found. Apparently if any differences in nutritive value of these corns (on a dry matter basis) exist for lambs, they are rather small.

Beef Cattle Experiments

Forty-four yearling hereford heifers were divided into four groups and started on the test. Three groups were fed the high-moisture corns previously described. One group was fed dry (14.5 percent moisture) corn from the same field. Eight heifers were removed from the test because they were found to be pregnant. In addition to corn

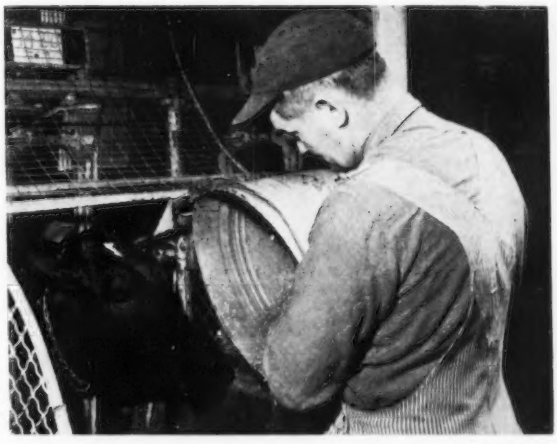


Fig. 3 Dairy cattle make efficient use of high-moisture corn

. . . Storage of Shelled Corn

TABLE 4. HIGH-MOISTURE CORN FOR FATTENING HEIFERS

Moisture content at harvest, percent	18	25	30	35
Moisture content when fed, percent	14.5*	24	29	36
Number of heifers	9	9	10	8
Average initial weight	738	770	743	754
Average daily gain	1.89	1.90	1.91	1.51
Average daily corn				
As fed	12.96	14.67	15.63	14.89
14.5 percent basis	12.96	13.03	12.99	11.15
Feed per hundred weight gain				
Corn (14.5 percent basis)	686.0	683.8	681.4	740.3
Hay	287.1	284.9	284.0	360.1
Soybean oil meal	74.9	74.3	74.6	93.5
Total	1048.0	1043.0	1040.0	1193.9
Feed cost per hundred-weight gain	$19.93	$19.84	$19.79	$22.58

*Artificially dried from 18 percent.

each heifer was fed 5.4 lb of mixed hay and 1.4 lb of soybean oil meal daily plus free-choice minerals.

The results in Table 4 show that corn stored at 24 or 29 percent moisture was equal to dry corn in feeding value. Heifers fed the 36 percent moisture corn consumed about two pounds per day less corn than heifers fed the other corns. This reduced intake results in slower and less efficient gains.

Swine Feeding Experiments

Forty-eight crossbred pigs averaging approximately 40 lb in weight were used for this test. Four groups of 6 pigs each were confined to ⅛-acre plots of alfalfa-ladino clover plots and four groups were confined to 7-by-14-ft pens on a concrete feeding floor. The four treatments were as follows:

TREATMENT

Shelled corn, 14 percent moisture, and supplement-free choice.
" " 25 " " " " " "
" " 30 " " " " " "
" " 25 " " " " " "

The supplement, supplementary protein plus vitamins, minerals and antibiotics, was available in a self-feeder in each lot. The corns were provided daily in open troughs.

Results of the first phase of the test, lasting 72 days, are shown in Table 5. The pigs getting the lowest moisture corn gained at the most rapid rate, and the slowest gains were realized on the 35 percent moisture corn. Average daily consumption of the three higher moisture corns was higher than the 14 percent moisture corn. This increase was not linear, however, and was not sufficiently greater to ensure equal dry matter intake. Thus, on the average, feed required per pound of gain was least on the 14 percent moisture corn. The pigs receiving 35 percent moisture corn consumed more supplement per pound of gain than did the pigs on the other treatments.

TABLE 5. RESULTS AFTER 72 DAYS ON TEST*

	Percent Moisture in Corn				
	14	25	30	35	
Average daily gain, lb					Avg.
Drylot	1.39	1.20	1.27	0.99	1.21
Pasture	1.24	1.02	1.10	0.87	1.06
Average	1.31	1.11	1.18	0.93	
Feed per day, lb					
Corn Drylot	4.06	4.51	4.47	4.51	4.39
Pasture	3.97	4.34	4.34	4.34	4.25
Supplement Drylot	0.82	0.86	0.84	0.85	0.84
Pasture	0.59	0.48	0.49	0.47	0.51
Feed per lb gain, lb					
Corn Drylot	2.92	3.76	3.52	4.56	3.69
Pasture	3.20	4.25	3.94	4.99	4.09
Supplement Drylot	0.59	0.72	0.66	0.86	0.71
Pasture	0.48	0.47	0.45	0.54	0.48

*Average initial weight of pigs was approximately 40 lb.

With increasing time on test, the pigs receiving the 30 and 35 percent moisture corns consumed proportionally more supplement than the others. Perhaps they "tired" of the high moisture corn, or perhaps the greater bulk, due to moisture content, prevented sufficient consumption to provide adequate dry matter intake.

These preliminary data show no nutritional advantage for high-moisture corns when fed free choice with supplement to growing-finishing swine.

High-Moisture Corn for Dairy Cattle

The feeding value of high-moisture corn for dairy cattle has been determined with 24 Holstein heifers and 27 milking cows. The high-moisture corn was harvested at three stages containing about 25, 30, and 35 percent moisture. The corn was stored in concrete-stave silos and removed from the silos with top unloaders daily.

In the heifer-feeding trial, four rations were fed including three kinds of high-moisture corn and one lot of regular corn. In addition to the corn, limited hay and soybean meal were fed to the four groups of heifers. The four kinds of corn were fed at rates to provide about the same amount of corn dry matter for all groups. The amount of hay fed was limited so that larger amounts of corn could be fed. Soybean meal was fed to all heifers at the rate of one pound daily. The results of feeding high-moisture corn to heifers are shown in Table 6.

TABLE 6. SUMMARY OF RESULTS OF FEEDING HIGH-MOISTURE CORN TO HEIFERS (16 WEEKS)

	Group I	Group II	Group III	Group IV
Percent moisture of corn:	25	30	35	14
Daily feed intake, lb				
Corn	7.8	8.3	9.0	7.0
SOM	1.0	1.0	1.0	1.0
Hay	8.3	8.3	8.3	8.4
Daily dry matter intake, lb				
Corn	6.1	6.1	6.0	6.0
SOM	0.9	0.9	0.9	0.9
Hay	7.4	7.4	7.4	7.5
Total	14.4	14.4	14.3	14.4
Weight gain per heifer, lb				
Total	153	167	161	186
Daily average	1.37	1.49	1.44	1.66
Heart girth increase, in.	5.8	6.0	5.8	6.1
Withers increase, cm	5.2	7.2	8.1	6.6
Feed efficiency (pounds of dry matter per pound of gain)	10.5	9.7	9.9	8.7

The regular corn (14 percent) was fed in the ground form. The high-moisture corn was fed as shelled corn as removed from the silos. High-moisture corn was softer than regular corn and, therefore, should have been more readily used without grinding. Whether or not grinding was needed to increase digestibility and utilization has not been determined. Also, this lot of regular corn was not produced on the same land as the high-moisture corn.

(Continued on page 309)

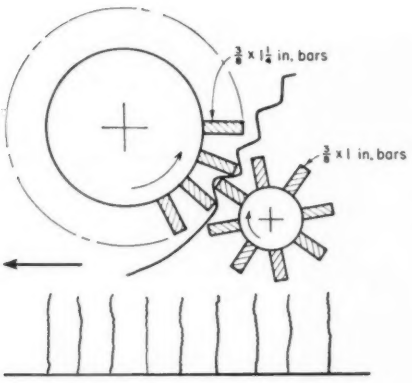


Fig. 1 Schematic, cross-sectional view of crimper C-1, drawn approximately to scale

Evaluation of Hay Conditioning Effects

R. A. Kepner, Member ASAE, J. R. Goss, Member ASAE, J. H. Meyer, and L. G. Jones

Curing rates, field losses, nutrient contents, and feeding response with crimped, rolled, and untreated alfalfa hay

TESTS at a number of agricultural experiment stations have demonstrated that hay crushed or crimped immediately after mowing dries considerably faster than untreated hay. Various tests have also indicated the relative effects of changing roll pressures and speed relations, and to some extent the influence of crop type, yield, and maturity. Although many reports have been published on hay conditioning, only a few contain any specific information on the nutrient contents of conditioned hay versus untreated hay. Only one report of comparative feeding trials (5)* has been found by the authors.

To obtain information regarding the desirability of hay conditioning in the interior valleys of California, field and laboratory tests were conducted at Davis during the 1958 season. These tests included all six cuttings of a 4-year-old alfalfa field. Drying rates in the field were determined, and samples for chemical analysis were taken at the time of mowing and just after baling. Field losses were determined after mowing and conditioning, and again after raking. Finally, feeding trials were conducted with sheep in the fall of 1958 and the fall of 1959.

Description of Conditioners

Two models each of smooth-roll crushers and crimpers were used in these tests. Roll diameters and operating conditions are summarized in Table 1. In general, smooth-roll machines crush the stems continuously throughout their length, whereas crimpers have intermeshing, fluted rolls that merely bend and crack the stems at intervals of 1 to 2 in. Smooth-roll machine No. R-1 (Table 1) had machined steel rolls that were smooth except for six longitudinal slots in the lower roll to aid in feeding. The steel rolls of machine R-2 had nearly twice the diameter of those of R-1, and the surfaces were somewhat irregular because they had not been machined. Crimper C-1 had rectangular steel bars on each roll, as shown in Fig. 1, whereas machine C-2 had malleable-cast-iron rolls with tapered flutes. With each of the crimpers, springs normally held the movable roll against stops that limited the amount of radial overlap to about 3/8 in. for the bars of machine C-1 (Fig. 1) and 5/8 in. (adjustable) for the flutes of machine C-2. The springs permit spreading of the rolls if a heavy slug of hay or some foreign object is encountered.

With either crimper, the movable roll was driven from the other one through the meshing of the bars or flutes. On crimper C-2, the contact was along the full length of the flutes, through the layer of hay. With crimper C-1, however, the bars on the lower roll had built-up sections 2-in. long at each end that provided a minimum tangential clearance of about 3/16 in. between adjacent bars of the two rolls (Fig. 1) in the crimping zone between the built-up sections.

Machine R-1 was equipped with a floating, spring-finger, pickup cylinder, whereas machine R-2 had a small-diameter, paddle-type pickup cylinder. The lower crimping roll on each of the other two machines served as the pickup (Fig. 1).

Field Layout and Harvest Procedure

Each cutting included an unconditioned treatment (referred to hereinafter as the control treatment) and two to four conditioned treatments. Machines R-1 and C-1 were used for all six cuttings, machine R-2 for four cuttings, and machine C-2 for two cuttings. In each treatment there were

TABLE 1. ROLL DIAMETERS AND OPERATING CONDITIONS

Machine identification	Type	Roll O.D., in. Lower	Roll O.D., in. Upper	*Ratio, roll periph. speed ÷ fwd. speed	Usual roll pressure, lb per in. length
C-1	Crimper	4	7½	4.4	19-21
C-2	Crimper	4	9	2.5	11-15
R-1	Smooth-roll	6⅜	6½	2.2	9-10†
R-2	Smooth-roll	12	12	2.8	16-22†

*Always operated in second gear, at a forward speed of about 4 mph.

†A few tests were made with roll pressures of 13½ lb per in. on R-1 and 32 lb per in. on R-2.

Paper presented at the Annual Meeting of the American Society of Agricultural Engineers at Ithaca, N. Y., June 1959, on a program arranged by the Power and Machinery Division.

The authors — R. A. KEPNER, J. R. GOSS, J. H. MEYER, and L. G. JONES — are, respectively, professor of agricultural engineering, assistant agricultural engineer, associate professor of animal husbandry, and specialist in agronomy, University of California, Davis.

Acknowledgment: The authors acknowledge the contributions of John R. Dobie, who assisted in conducting the field tests and was responsible for making the pellets used in the feeding trials, and of R. G. Curley, who also helped in making the field observations.

*Numbers in parentheses refer to the appended references.

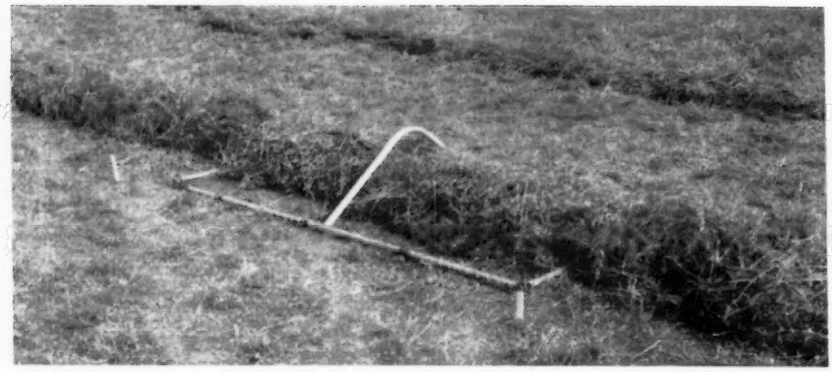


Fig. 2 *(Left)* Section of windrow on a flexible-netting tray for determination of drying rates. *(Below)* Weighing a tray. The portable box shields the tray from wind during weighing

four randomized replications, each consisting of the center two-thirds of an irrigation check 38 ft wide and 240 ft long.

The checks were mowed in successive pairs, starting at 8:30 to 9:15 a.m. (PDT) and finishing within 2 hr. By having a tractor available for each conditioner, it was possible to follow the mower, without interruption, with whatever machine was scheduled for a particular check. Except for one special test, the hay was conditioned within 15 min after being mowed.

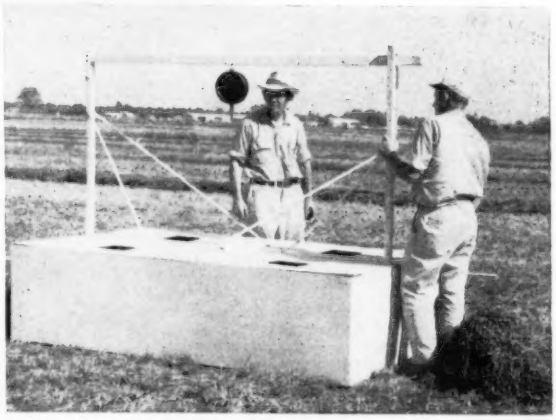
For most cuttings the hay was raked on the morning after mowing, putting the 25 to 28-ft-wide test strip of each check into a single windrow. Raking was done while the hay was still tough from the moisture picked up during the preceding night. Except for the third cutting and the control treatment in the sixth cutting, the windrows were not turned after the initial raking.

Baling was always done in the morning, starting soon after the free moisture had disappeared from the windrows and finishing before the hay became dry enough to cause appreciable leaf shatter. Bales averaging about 100 lb in weight (14 lb per cu ft) were made with a two-wire automatic baler.

For all cuttings except the first one, a portable weather station was set up in the test field. Dry-bulb and wet-bulb air temperatures and wind velocity, all at a 3½-ft elevation, and air temperatures beneath the swath or in the center portion of the windrow, were recorded.

Sampling Methods

In any study involving a product as variable as hay, sampling techniques need careful consideration since they may have a marked influence on the values obtained and the reliability of the results. Two methods were used in determining windrow moisture content. One involved periodic weighing of sections of windrows left on trays during the curing period (Fig. 2). The other required the cutting out and artificial drying of 1-ft sections from each windrow every time moisture determinations were made. The trays permitted more frequent observations of moisture content without the necessity of drying an excessive number of samples. During the first two cuttings, windrow samples were taken each morning and evening. For the remainder of the cuttings, one tray was placed in each check (four per treatment) and windrow samples ordinarily were taken only on the last morning, just before baling. All moisture samples were suspended in cloth bags in a forced-air fruit dehydrator and dried for several days at about 130 F.



Comparisons between the trays and the windrow samples indicated that considerable care was necessary in placing the trays to ensure about the same drying rate as in the undisturbed windrows. Trays having ⅓-in. wire-mesh bottoms tended to be held too high by the stubble and sometimes dried too fast. Results were more reliable with trays consisting of 1-in.-mesh badminton netting stretched on a thin-wall conduit frame (40 x 76 in.). The flexible netting permitted more natural resting of the windrow on the stubble, as shown in Fig. 2.

Moisture content of the hay while in the swath was determined by picking up a 2 to 3-lb sample from each check, taking one handful at a time as the observer traversed the length of the check. It was found impractical to use the trays for observations of swath moisture content because of the small amount of hay involved and because the hay on the trays dried more rapidly than the undisturbed hay. Bale moisture content at the time of baling was determined by opening one bale per check and drying a 2 to 3-lb sample taken from each quarter of the bale.

Samples for determination of protein, carotene, and crude fiber contents of the baled hay were obtained with a push-type probe inserted into one or both ends of the bale to a depth of 16 to 18 in. A probe that cut a ¾-in.-diameter core was used for most cuttings, although comparative tests with a ⅜-in. probe and two types of rotating sampling devices were conducted during several cuttings.

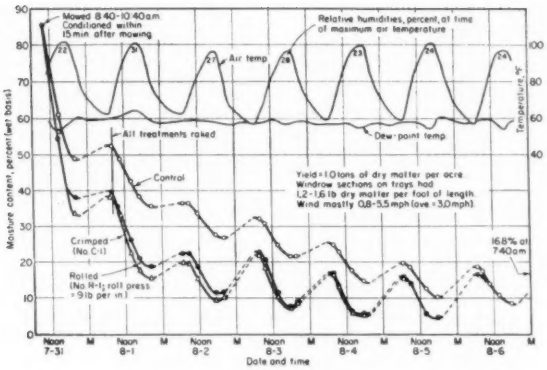

Mowed 8:40-10:40 a.m.
Conditioned within 15 min after mowing
Relative humidities, percent, at time of maximum air temperature
Air temp.
Dew-point temp.
All treatments raked
Control
Crimped (No. C-1)
Rolled (No. R-1; roll press 9 lb per in.)
Yield = 1.0 tons of dry matter per acre
Windrow sections on trays had 1.2-1.6 lb dry matter per foot of length.
Wind mostly 0.8-5.5 mph (ave = 3.0 mph)
16.8% at 7:40 a.m.
Moisture content, percent (wet basis)
Temperature, °F
Noon 7-31
Noon 8-1
Noon 8-2
Noon 8-3
Noon 8-4
Noon 8-5
Noon 8-6
Date and time

Fig. 3 Field drying rates for the fourth cutting, under typical summer weather conditions

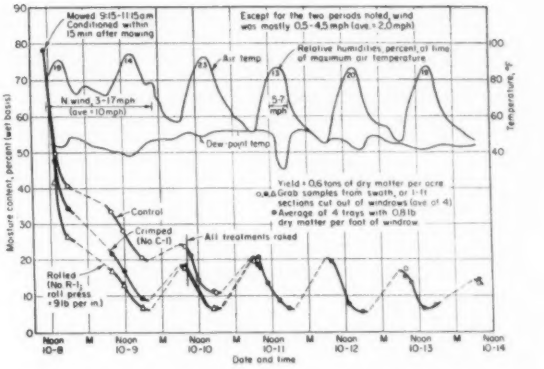

Mowed 9:15-11:15 a.m.
Conditioned within 15 min after mowing
Except for the two periods noted, wind was mostly 0.5-4.5 mph (ave. = 2.0 mph)
Air temp.
Relative humidities, percent, at time of maximum air temperature
N wind, 3-17 mph (ave = 10 mph)
5-7 mph
Dew-point temp.
Yield = 0.6 tons of dry matter per acre
Grab samples from swath, or 1-ft sections cut out of windrows (ave of 4)
Average of 4 trays with 0.8 lb dry matter per foot of windrow
Control
Crimped (No. C-1)
All treatments raked
Rolled (No. R-1; roll press 9 lb per in.)
Moisture content, percent (wet basis)
Temperature, °F
Noon 10-8
Noon 10-9
Noon 10-10
Noon 10-11
Noon 10-12
Noon 10-13
Noon 10-14
Date and time

Fig. 4 Field drying rates for the sixth cutting, with a light crop and a north wind during the first 36 hours after mowing

Drying Rates

Fig. 3 shows drying rates for the fourth cutting, under summer weather conditions typical for the Sacramento Valley. Note that part of the advantage of faster daytime drying of conditioned hay was lost by greater moisture pick-up during the night. The fifth-cutting crop and weather conditions and drying rates were about the same as for the fourth cutting. In the first two cuttings, with higher relative humidities and maximum temperatures averaging only about 80 F instead of 100 F (Table 2), each treatment dried at about the same rate as the corresponding fourth-cutting treatment during the first 3 or 4 days, but slower thereafter.

In the third cutting, the conditioned treatments were raked about 3 hr after mowing, when the hay was slightly wilted (about 65 percent moisture content). The control treatment was not raked until the next morning (at 50 percent moisture). The retarding effect of the early windrowing of the conditioned hay very nearly counteracted the advantage usually gained from conditioning, with the control and the crimped treatments drying at about the same rate during the first two days.

Drying rates for the sixth cutting are presented in Fig. 4 as an example of fast drying during the first two days, when there was a moderately strong wind, a light crop, and high temperatures throughout the night. There was no dew on the first morning after mowing, and barely enough for raking on the second morning. Thereafter, wind velocities were low and humidities more normal, with heavy dew each morning. Moisture contents of all three treatments were about the same on the third morning after mowing, with the conditioned treatments actually higher than on the second morning.

In general, there was no great difference in drying rates obtained with the four conditioners. Smooth-roll machine R-1 tended to be slightly slower than crimper C-1 when the roll pressure was 9 to 10 lb per in., but slightly faster when the roll pressure was 13½ lb per in. Drying-rate curves for the two crimpers checked rather closely, and there was not much difference between smooth-roll crusher R-1 at a roll pressure of 9 to 10 lb per in. and machine R-2 at 16 to 22 lb per in. Machine R-2 required a higher roll pressure than R-1, primarily because of the larger diameter of the rolls and the resulting greater contact area on the hay. The difference may have been partly due to the irregularity of the roll surfaces (which resulted in uneven crushing).

Reports from two other experiment stations (1, 3) have indicated that it is possible for conditioned alfalfa hay to dry to 20 percent moisture content within 6 to 8 hr after mowing and be ready for baling by late afternoon; but moisture contents of the standing crop were only 70 to 75 percent, as compared with 80 to 85 percent for the tests reported herein (Table 2). Moisture data obtained during the first two days after each of several cuttings in Minnesota tests (6) check rather closely with the curves of Fig. 3.

TABLE 2. SUMMARY OF HARVEST CONDITIONS AND CURING TIMES

Cutting No.	1	2	3	4	5	6
Date mowed	4-29	6-3	7-7	7-31	8-28	10-8
Percent bloom	10	20	56	9	9	50
Percent initial moisture content	80	81	81	85	82	79
Yield, tons per acre at 15 percent moisture	1.7	1.55	1.8	1.2	1.2	0.7
Weather conditions during curing period						
Ave., daily min. temp., deg F	47	54	54	59	56	71-49*
Ave. daily max. temp., deg F	82	77	98	99	94	93-89*
Usual dew-point range, deg F	45-50	45-55	53-60	55-63	54-60	40-55
Ave. wind velocity, mph	—	3.9	2.4	3.0	3.3	10.2-2.0*
Estimated days to dry to early-morning moisture content of 20 percent						
Control	7	8†	4	6	6	4
Crimped	5	3	4‡	4	4	2§
Rolled	5	4	4‡	4	4	2§

*First figure is for first 36 hours after mowing; second figure represents remainder of curing period (see Fig. 4).
†Showers on sixth day. No other rain during any of the cuttings.
‡The rolled and crimped treatments were raked 3 hr after mowing, whereas the control was not raked until the next morning.
§No dew, so baling could not be done until third morning after mowing.

. . . Hay Conditioning

TABLE 3. FIELD LOSSES FROM MOWING AND CONDITIONING

(Average for second, third, and fourth cuttings)

Treatment	Total loss		Loss due to conditioning, percent of yield
	Pounds dry matter per acre	Percent of yield	
Control	27*	1.0	0.0
Crimped (C-1)	121*	4.6	3.6
Rolled (R-1)	54*	2.1	1.1

Average yield was 2600 lb of dry matter per acre.

Maturity ranged from 9 to 56 percent bloom.

*Differences between all treatments were significant, at the 1 percent level.

Time of Baling

Moisture levels at the time of baling ranged from 26 percent, for an early baling of part of the first-cutting control, to 12 percent, for conditioned hay in the third cutting. Most of the other balings were at moisture contents of 15 to 23 percent. In general, it was found that anything baled at an average moisture content above 16 to 17 percent developed some mold in storage, and anything baled above 20 percent heated sufficiently to impart a brown color to the hay.

If 20 percent moisture is considered to be the upper safe limit for baling, then field curing times in the first five cuttings would have ranged from 4 to 8 days for the unconditioned hay and from 3 to 5 days for the conditioned hay (Table 2). These times are for maximum *early-morning* moisture contents not greater than 20 percent. An additional one or two days would be required to reach 16 percent.

The conditioned hay often dried to 20 percent moisture within 30 to 35 hr after mowing, but afternoon baling is not considered practical in the interior valleys of California, because of low relative humidities and the resulting high shatter losses. Baling at night, after the hay has picked up enough moisture to become tough but not enough to exceed the upper safe limit, is common practice in some areas of the state and might reduce the curing times mentioned in the preceding paragraph. Sometimes, however, there is not enough dew for baling even in the early morning, in which case the advantages of faster curing of conditioned hay may be lost.

In general, conditioning usually reduced the minimum required field curing time by about 2 days. In the second cutting, however, showers occurred after the conditioned hay had been baled and while the control was still in the windrow, thus increasing the difference in curing times to 4 days.

Field Losses

The field losses evaluated in these tests consisted of freshly cut plant material—primarily shattered leaves, tips of plants, short sections of stalk, and short pieces of leaf branches—that ordinarily would not be recovered in the raking operation. This material was picked up by hand from 2 by 6-ft areas soon after mowing and conditioning and again after raking. To permit picking up material for the first set of samples, a special fork arrangement was used to carefully lift and set aside a section of the swath in each check.

Table 3 shows average losses for three cuttings in which the roll pressure was 9 to 10 lb per in. for machine R-1. All differences between treatments were statistically significant at the 1 percent level. The 1.1 percent increase in loss as a result of rolling is not economically important, but the 3.6 percent increase due to crimping does represent an appreciable loss of income. Both crimping and rolling losses were considerably less in the first cutting than in later cuttings. Because of the predominance of leaves and stalk tips, the protein content of the material lost in the conditioned treatments averaged several percentage points higher than the protein content of the baled hay.

Total losses determined after raking averaged practically the same as those obtained after conditioning (i.e., no significant change due to raking). Losses were about the same for both crimpers, and there was no significant difference between the results for the two smooth-roll crushers at roll pressures of 9 to 10 lb per in. for machine R-1 and 16 to 22 lb per in. for R-2. Increasing the roll pressure of machine R-1 from 9 lb per in. to 13½ lb per in. increased the total loss by 50 to 60 percent (significant at the 5 percent level). The loss from machine R-2 was also greater at higher roll pressures.

Nutrient Contents

Protein and crude fiber contents for the hay just after baling and for the pellets and bales as fed are shown in Table 4. Values in different columns are not comparable unless they represent the same group of cuttings. Crude fiber content is a readily determinable and reliable index of TDN content (total digestible nutrients). The relation is an inverse one, with high crude fiber content being undesirable.

At the time of baling, the crimped hay had a significantly higher crude fiber content and lower protein than the other two treatments. At the time of feeding, after storage periods of 1½ to 16 months, the differences were less pronounced and not statistically significant. With the unconditioned hay and the rolled hay, protein contents after baling were essentially the same as for the standing crop at the time of mowing. Comparisons of values when fed and values for the corresponding cuttings when baled (not possible in Table 4) indicate no significant change in protein or crude fiber contents during storage.

In the third, fourth, and fifth cuttings, carotene contents at the time of baling ranged

TABLE 4. PROTEIN AND CRUDE FIBER CONTENTS OF HAY

	Average values, percent of dry matter					
	Just before mowing (cuttings 2-6, incl.)	Just after baling (cuttings 2-6, incl.)	At the start of feeding*			Refused by sheep (from bales, cuttings 1,4,5)
			Cuttings 1,4,5 (fall, 1958)		Cuttings 2,3,6, pellets	
			Bales	Pellets		
Crude fiber						
Control	—	27.4†	27.8	27.8	26.2	42.0
Crimped	—	28.8†	28.5	28.2	26.9	42.1
Rolled	—	28.2	27.3	27.8	27.7	43.2
Crude protein						
Control	22.3	22.5†	22.3	21.4	21.7	13.7
Crimped	22.3	21.6†	21.7	21.4	21.0	12.1
Rolled	22.3	22.0	21.7	21.9	21.6	12.9

*1½ to 5½ months after mowing, for cuttings 1, 4, and 5; 12 to 16 months after mowing, for cuttings 2, 3, and 6.

†Differences between crimped and control treatments were significant at the 5 percent level.

from 17 to 55 ppm (parts per million), as compared with 250 to 280 ppm when mowed. The carotene in the conditioned treatments averaged 13 percent of the initial amount, whereas the control averaged 11 percent. In the sixth cutting, when the hay dried very rapidly because of the north wind (Fig. 4), the conditioned treatments averaged 120 ppm when baled, as compared with 80 ppm for the control and 390 ppm when mowed. But, after being in storage for four months, the sixth-cutting conditioned treatments had only 42 ppm as compared with 54 ppm in the control. In other words, the advantage of conditioned hay in regard to carotene content at the time of baling disappeared during storage.

TABLE 5. SUMMARY OF FEEDING RESPONSE WITH SHEEP

	Average daily gain, lb		Pounds gain per 100 lb feed consumed (dry matter)		Adjusted daily gain*	
	Cuttings 1,4,5 (fed, 1958)	Cuttings 2,3,6 (fed, 1959)	Cuttings 1,4,5 (fed, 1958)	Cuttings 2,3,6 (fed, 1959)	Cuttings 1,4,5 (fed, 1958)	Cuttings 2,3,6 (fed, 1959)
Pelleted hay						
Control	0.31	0.23	9.9	8.8	0.28	0.21
Crimped	0.28	0.21	9.5	8.4	0.27	0.20
Rolled	0.37†	0.14	11.9†	6.1	0.35†	0.18
Bales						
Control	0.26	—	9.3	—	0.29	—
Crimped	0.25	—	9.1	—	0.28	—
Rolled	0.30†	—	10.5†	—	0.31†	—

*Average daily gains adjusted by regression analysis to the following average daily feed intakes: cuttings 1, 4, 5 — 2.94 lb per day; cuttings 2, 3, 6 — 2.50 lb per day.

†In 1958 trials, differences between rolled and other two treatments were significant at the 5 percent level.

Feeding Trials

Feeding trials with sheep were started in October, 1958, and continued for a period of 8 weeks, using rolled, crimped, and unconditioned hay from the first, fourth, and fifth cuttings. These cuttings were selected because the maturity of the hay when cut was about the same (9 to 10 percent bloom) for all of them. Part of the hay from each field treatment for each cutting was pelleted (⅜-in. diameter) and part was fed directly from the bale. This made a total of 18 pens, each with two sheep.

Because the 1958 feeding results showed a significant difference in favor of rolled hay that was not explainable in terms of chemical content, additional feeding trials were conducted in the fall of 1959, using hay from the other three 1958 cuttings. Only pelleted hay was used in the 1959 trials (none fed directly from the bale). Maturity of the hay in these cuttings ranged from 20 to 56 percent bloom (Table 2).

The results of the 1958 and 1959 trials are summarized in Table 5. In the 1958 trial, average daily gain and gain per unit of feed consumed were significantly greater with rolled hay than with either of the other two treatments. But when the remainder of the 1958 hay was fed to another lot of sheep in 1959 there was a tendency for reversal of the earlier results, although the differences were not statistically significant. Another comparison in 1959 between rolled and unconditioned hay (none was crimped) showed no significant difference in feeding response. This latter comparison was part of an extensive sheep feeding trial at Davis with 1959 second-cutting hay in which part of the hay was chopped after baling and the remainder of the bales were pelleted.

The average amounts of baled hay refused by the sheep in the 1958 trial ranged from 14 to 24 percent for the three cuttings, with no significant differences between crimped, rolled, and unconditioned hay within cuttings. In none of the three feeding trials was there any significant effect of conditioning upon average daily feed consumption.

Even though significant differences in response were found in the first trial, consideration of the results from all three trials indicates that conditioning hay with either a crimper or a smooth-roll machine has no consistent effect on the feeding response with sheep. Moreover, the small differences between chemical analyses of hay from the three treatments would not lead one to expect any great differences in animal response. Also, earlier tests with dairy cows at the Pennsylvania Agricultural Experiment Station, reported in 1948 (5), showed no difference between crushed and unconditioned hay when milk production and body-weight changes were the criteria during 20-day test periods.

Apparently the statistically significant response differences in 1958 were due to chance,† since the results could not be repeated in two other tests. Differences in the 1959 tests with 1958 hay, although relatively large in terms of average values, did not approach significance because of wide variations between responses for individual animals. The sheep used in 1959 consumed less feed per day and gained less per unit of feed than did the 1958 sheep.

The 1958 feeding trials afford an interesting comparison between pelleted hay and baled hay. The first-cutting hay was somewhat weedy and had heated in storage because of the high moisture content when baled. Sheep fed on pellets made from this hay averaged 46 percent greater daily gain and consumed 18 percent more feed per day than did those fed from the bales. The net result was a 27 percent greater gain per 100 lb of feed consumed. Considering that 24 percent of the baled hay was refused whereas there was no waste with the pellets, the gain per 100 lb of feed *supplied* was about 65 percent greater with pellets than with baled hay. These results represent averages for all three treatments (crimped, rolled and unconditioned).

With good hay from the fourth and fifth cuttings there was no significant difference between pellets and bales in regard to the average gain per 100 lb of feed consumed (Table 4), but a 16 percent waste from the bales resulted in the pellets averaging 20 percent more gain per 100 lb of feed supplied.

Operating Characteristics

Field experience with the various conditioners during these tests was too limited to yield much information about operational problems. None of the machines gave any appreciable trouble with clogging of rolls. However, it was noted that the spring-finger pickup cylinder on machine R-1 was considerably more effective than the pickup rolls of the other three conditioners, particularly when operating over rough ground or with one wheel on an irrigation levee.

Justification for Conditioning

The farmer who conditions his hay has the added costs and problems of an extra operation with a special piece of

†Statistical significance at the 5 percent level implies one chance in 20 that the observed difference is not due to the treatment.

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equipment. He will also have some additional field loss of hay due to the conditioning operation. In attempting to justify the use of a conditioner, consideration must be given to such factors as *(a)* the possibility of improved feeding response or a higher price per ton, *(b)* possible savings on hay that otherwise might be lost or damaged because of bad weather, *(c)* the possibilities and importance of improved scheduling of other operations in the haymaking sequence, and *(d)* possible reduction in time or labor required for the other operations.

As indicated in a preceding section, the tests at Davis show no consistent advantage of conditioning in regard to the feeding response with sheep. Unless the buyer does get better response, he cannot afford to pay a premium price for conditioned hay. Fast curing to reduce the chances of damage due to bad weather is of far less importance in California than in the midwestern and eastern states. Evaluation of items *(c)* and *(d)* will depend to a large extent on the conditions existing in a particular situation.

Summary

Conditioned hay often dried to 20 percent moisture content by the end of the second afternoon after mowing (30 to 35 hr), but a curing time of 3 to 5 days was required to reach an early-morning moisture content of 20 percent for baling. Under the conditions of these tests, part of the advantage of faster daytime curing of conditioned hay was lost by greater moisture pickup at night. Curing times with either crimpers or smooth-roll crushers were usually 2 days less than for unconditioned hay.

Field losses due to mowing and conditioning exceeded those due to mowing without conditioning, by an average of 1.1 percent of the crop with the smooth-roll crushers at moderate roll pressures and 3.6 percent of the crop with the crimpers.

Crimped hay averaged about ½ percentage point lower in protein and 1 percentage point higher in crude fiber than rolled or unconditioned hay. Conditioned hay showed a slight advantage in carotene content at the time of baling, but no advantage after several months of storage.

In feeding trials with sheep there were no consistent differences between results obtained with crimped, rolled, and unconditioned hay.

When first-cutting hay was fed to sheep, the gain per 100 lb of feed supplied (including waste) was 65 percent greater with pellets (made from bales) than with baled hay fed direct. With good hay from two other cuttings, the advantage was only 20 percent.

References

1 Bruhn, H. D. Status of hay crusher development. AGRICULTURAL ENGINEERING, 36:165-170, March 1955.

2 Jones, T. N. and Dudley, R. F. Methods of field curing hay. AGRICULTURAL ENGINEERING, 29:159, 161, April 1948.

3 Luttrell, Houston. Hay conditioning in Tennessee. Paper presented at meeting of Southeast Section, ASAE, Memphis, Tennessee, February 1959.

4 Ramser, J. H. and Kleis, R. W. Hay crushing for faster curing. *Illinois Agr. Ext. Circ.* 693, 1952.

5 *Science for the Farmer.* 61st Annual Report of Pennsylvania Agr. Expt. Sta., Bull. 502: 7, June 1948.

6 Strait, John; Marvin, R. P., and Fielder, B. H. Mechanical treatment speeds field drying of hay. *Minnesota Farm and Home Science* 15(3):17, 18, May 1958.

7 Zachariah, P. John; Elliott, K. C., and Phillips, R. A. Performance of forage crushers. *West Virginia University Agr. Expt. Sta.*, Bull. 418, 1958.

FARMSTEAD ENGINEERING CONFERENCE IN SEPTEMBER

PLANS for the Farmstead Engineering Conference on confinement housing of livestock to be held at the University of Illinois, Urbana, September 13-15, are progressing on schedule. The event is sponsored by the American Society of Agricultural Engineers, Farm Structures Division, in cooperation with the Agricultural Engineering Research Division, ARS, USDA, and Departments of Agricultural Engineering and University Extension, University of Illinois.

Its purpose is to collect and disseminate the most current information on all factors affecting confinement housing of livestock and to summarize and bring into focus basic and functional design requirements relating to engineering farmstead and housing systems. Its objectives are: (a) To present the most advanced information from the standpoint of management, breeding, feeding, sanitation, marketing, and other future considerations which may affect farmstead engineering; (b) to present basic and functional requirements of animals in a way that is useful to designers; (c) to present design procedures and solutions for combinations of components for economical operation; (d) to point up areas in which basic research is needed; (e) to focus attention on cost vs. returns of engineering housing systems; (f) to focus attention on power requirements of engineered farmsteads; and (g) to publish this material in a special issue of the Journal for easy reference.

One-half day sessions will be devoted to each of the following: Poultry, swine, dairy, and beef. One evening session will be devoted to cost vs. returns from engineered farmsteads, and meeting capital requirements for engineered farmsteads. The second evening will consist of a dinner meeting in which future farmstead power requirements, and from where will the power come, will be discussed. On the afternoon of the third day, a tour of research installations is being planned.

The opening session will be held on Tuesday afternoon, September 13, and will be devoted to a Poultry program. T. C. Byerly, deputy administrator, Agricultural Research Service, USDA, will give the keynote address, and discussions on the functional and basic requirements of poultry housing; and combination of components for economical operation for poultry will follow.

O. Burr Ross, head, animal science department, University of Illinois, will give the keynote address at the Wednesday morning program, which will be devoted to swine. The program will consist of talks on the functional and basic requirements of swine housing; and combination of components for economical operation. The session on Wednesday afternoon, at which Woodrow Snyder, department of dairy, Michigan State University, will deliver the keynote address, will be a dairy program. The functional and basic requirements of dairy housing, and the combination of components for economical operation will be included in the program. Albert E. Darlow, vice-president, agricultural sciences, Oklahoma State University, will give the keynote address at the Beef program scheduled for Thursday morning. Functional and basic requirements of beef housing, combination of components for economical operation, and the farmstead of the future, will also be included on this program. A tour of research installations on Thursday afternoon will conclude the three-day conference.

The September issue of AGRICULTURAL ENGINEERING will be devoted entirely to farmstead engineering and by reason of the scope of the material it will contain, including all papers presented at the Conference, promises to be a comprehensive handbook on the subject, suitable for the engineer, manufacturer, dealer, and farmer alike.

Engineering Use of Soil Surveys

Elvin F. Henry
Affiliate ASAE

FHA employs National Soil Survey data in residential construction

WHILE the soil is one of the most common engineering materials, surprisingly little is known about its behavior or engineering qualities relating to residential development. This is especially true of the so-called "problem" soils.

Since most soils are at least useful and productive to some degree for agricultural purposes, many of us expect them to behave uniformly when used for various engineering purposes. Many builders are still complacent, indifferent and uninformed as to the many extreme inherent complexities of soils when used for various engineering purposes.

Some agriculturists are able to identify, select and utilize soils according to their individual characteristics. A larger proportion, however, accept the soil as it is, unaware of significant inherent differences. This philosophy has carried over into the more intensive use of soils in residential development. Only in recent years has it become necessary that soil engineering behavior be studied more carefully, in order to meet more rigid engineering standards.

Concurrent with this trend, as well-drained, workable, agricultural soils diminish, particularly around fast-growing cities, the use of marginal and even submarginal lands is becoming widespread. Some land developers, contractors and builders are wisely using the soils in these areas after careful identification and selection following sound engineering practices. Others, due to lack of knowledge or indifference, are subjecting many unsuspecting homeowners to serious problems arising from soil deficiencies.

The Architectural Standards Division of the Federal Housing Administration recognized these soil problems years ago and made definite long-range plans to find solutions,

Paper presented at the Annual Meeting of the American Society of Agricultural Engineers at Ithaca, N. Y., June 1959, on a special Public Lands and Public Works program.

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TABLE 1 Unified soil classification

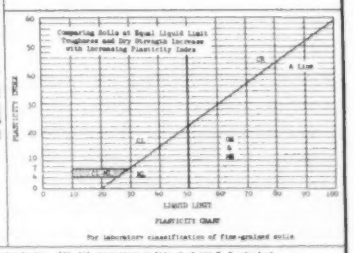
UNIFIED SOIL CLASSIFICATION
[Including Identification and Description]

Major Divisions		Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Information Required for Describing Soils	Laboratory Classification Criteria
1	2	3	4	5	6	7
Coarse-grained Soils: More than half of material is larger than No. 200 sieve size.	Gravels: More than half of coarse fraction is larger than No. 4 sieve size. Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.		Not meeting all gradation requirements for GW
	Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixture.	Nonplastic fines or fines with low plasticity (For identification procedures see ML below).	Give typical name; indicate approximate percentages of sand and gravel; maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information, and symbol in parentheses.	Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
		GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).		Atterberg limits above "A" line with PI greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size. Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.	Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size, rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength, well compacted and moist in place, alluvial sand, (SM).	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.		Not meeting all gradation requirements for SW
	Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (For identification procedures see ML below).		Atterberg limits below "A" line or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols
		SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).		Atterberg limits above "A" line with PI greater than 7
Fine-grained Soils: More than half of material is smaller than No. 200 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)				Identification Procedures on Fraction Smaller than No. 40 Sieve Size		Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% — GW, GP, SW, SP. More than 12% — GM, GC, SM, SC. 5% to 12% — Borderline cases requiring use of dual symbols.
				Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)
Silts and Clays: Liquid limit is less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight
Silts and Clays: Liquid limit is greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium
		CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium
Highly Organic Soils		Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.		

For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.

Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor, if any, local or geologic name and other pertinent descriptive information, and symbol in parentheses.

Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).



PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as micalike clays and organic clays which occur below the A-line. Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

TABLE 2 Disturbed soils

MAJOR DIVISIONS (1)	(2)	GROUP SYMBOLS (3)	TYPICAL NAMES OF SOIL GROUPS (4)	GENERAL CHARACTERISTICS[1] Workability as a Construction Material (5)	Compaction Characteristics (6)	Unit Dry Weight lb per cu ft (7) Std. AASHO	Mod. AASHO	Shearing Strength when Compacted and Saturated (8)	Compressibility when Compacted and Saturated (9)	Expansion Potential when Compacted (10)	Permeability and Percolation Characteristics when Compacted cm per sec (11)
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	1	1	125-135	125-140	1	1	1	$K > 10^{-2}$ Pervious
		GP	Poorly graded gravels or gravel-sand mixtures little or no fines.	2	2	110-125	110-140	2	1	1	$K > 10^{-2}$ Very pervious
		GM	Silty gravels, gravel-sand-silt mixtures.	2	4	115-135	115-145	5	2	1	$K=10^{-3}$ to 10^{-6} Semi-pervious to impervious
		GC	Clayey gravels, gravel-sand-clay mixtures.	2	3	115-130	120-145	6	3	2	$K=10^{-6}$ to 10^{-8} Impervious
	SANDS AND SANDY SOILS	SW	Well-graded sands, gravelly sands, little or no fines.	1	1	105-120	110-130	3	1	1	$K > 10^{-3}$ Pervious
		SP	Poorly graded sands or gravelly sands, little or no fines.	3	2	100-120	105-135	4	1	1	$K > 10^{-3}$ Pervious
		SM	Silty sand, sand-silt mixtures.	3	4	100-125	100-135	7	3	1	$K=10^{-3}$ to 10^{-6} Semi-pervious to impervious
		SC	Clayey sands, sand-clay mixtures.	2	3	105-125	110-135	8	3	2	$K=10^{-6}$ to 10^{-8} Impervious
FINE-GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	3-4	4-6	85-115	90-125	9	4	2	$K=10^{-3}$ to 10^{-6} Semi-pervious to impervious
		CL	Inorganic clays of low to medium plasticity gravelly clays, sandy clays, silty clays, lean clays.	3	4	90-120	90-130	9	5	3	$K=10^{-6}$ to 10^{-8} Impervious
		OL	Organic silts and organic silty clays of low plasticity.	4	7	80-100	90-105	9	6	3	$K=10^{-4}$ to 10^{-6} Semi-pervious to impervious
	SILTS AND CLAYS LL IS GREATER THAN 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	4	4-8	70-95	80-105	10	6	2	$K=10^{-4}$ to 10^{-6} Semi-pervious to impervious
		CH	Inorganic clays of high plasticity, fat clays.	5	4-7	75-105	85-115	10	7	3	$K=10^{-6}$ to 10^{-8} Impervious
		OH	Organic clays of medium to high plasticity, organic silts.	5	8	65-100	75-110	10	7	3	$K=10^{-6}$ to 10^{-8} Impervious
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils	NS	NS	NS	NS	NS	NS	NS	NS
TEXT REFERENCE (Paragraph Number)				32	33	34		35, 36	37, 38, 39	40, 41, 42	43, 44, 45

Notes: 1. Numbers in each column indicate relative desirability. The numeral "1" is used for the group or groups usually considered most desirable; higher numbers indicate desirability decreasing with the magnitude of the numbers. The symbols "NS" indicate that a soil group is not generally suitable for the use shown or, in the rating of characteristics, its quality is so poor that no relative rating is assigned. In the columns stating the relative ratings of the soil groups with reference to unfavorable characteristics, such as compressibility and potential frost action, it should be kept in mind that the groups which show little evidence of these unfavorable characteristics are given the lower numerical ratings; on the other hand, where groups are compared with reference to favorable characteristics, such as workability and shearing strength, the groups which show greater evidence of these features are given the lower numerical ratings. Numerical comparisons apply only within a single vertical column. It should be clearly recognized that the numerical ratings given are approximate and are intended only as a guide to aid the investigator in comparing soils for various purposes.

2. Fills are not generally suitable for use as domestic sewage disposal areas except for coarse-grained soils on coarse-grained subgrades with favorable topography, and the fills that are used should be large, well designed and properly compacted.

through its Technical Studies Program, to assure the modern homeowner of a safe, sound and satisfactory place to live. A well-planned program of soils engineering is being devised and put into operation. Some of these problems involve the use of soils for individual absorption fields, beds or pits for the disposal of sewage effluent. Extensive research projects are being conducted under the FHA Technical Studies Program relative to the satisfactory use of seepage pits and beds. Investigations as to soil parameters to gauge the effectiveness of these methods of disposal are being thoroughly covered.

The rapidly increasing problem of unstable or expansive soils is also being studied. A study on the design of slabs under residential construction, involving soil instability, is being completed. In this study, soil engineering data are interpreted through the Unified Soil Classification System. Slab design, reinforcement and foundation factors involving soils are given full consideration.

Since a large proportion of modern one and two-story residential structures are being constructed over filled, disturbed or "made" soils, it becomes essential that engineering knowledge as to identification, classification and methods of processing these disturbed soils be brought up to date. A modest start has been made to study, for this specific use, such things as soil compaction and soil stabilization. Methods of identification and control of inherent soil weakness in the undisturbed state, such as soil subsidence and soil slides, are also being considered.

The Sanitary Engineering Section of the Federal Housing Administration is now developing standards for use in the construction of sewage oxidation ponds. The identification and evaluation of soils used as embankments or as core

at residential building sites

		RELATIVE DESIRABILITY FOR VARIOUS USES[1]								
		Roadways					Foundations	Water and Sewerage Purposes		
Potential Frost Action (12)	Corrosion Potential (13)	Sub-base when not Subject to Frost Action (14)	Base when not Subject to Frost Action (15)	Sub-base when Subject to Frost Action (16)	Wearing Surface (untreated) (17)	Surface Stabilization with Additives (18)	Low Buildings on Compacted Fill (19)	Low Berm for Sewage Lagoons (less than 6 ft) (20)	Compacted Earth Lining for Water Storage Reservoirs and Sewage Lagoons (21)	Domestic Sewage Disposal Area[2] (22)
1	1	1	1	1	3	1	1	NS	NS	1
1	1	3	2	3	4	2	2	NS	NS	1
2-3	1	4	2-4	6	5	1	3	2	4	2
2-3	2	4	3-4	5	1	2	4	1	1	2
1	1	2	2	2	5	1	2	NS	NS	1
1	1	5	2-4	4	5	1	4	NS	NS	1
4	1	6	3-5	8	6	2	4	4	5	2
4	2	6	5	6	2	2	5	3	2	NS
3-5	2	8	NS	10	NS	3	7	6	6	NS
3-4	3	7	NS	7	7	4	6	5	3	NS
3-4	4	9	NS	11	NS	5	8	8	7	NS
3-5	2	10	NS	12	NS	5	9	9	8	NS
3	3	11	NS	9	NS	6	8	7	7	NS
3	4	12	NS	13	NS	6	10	10	NS	NS
2	5	NS	NS	NS	NS	NS	NS	NS	NS	NS
46	47	48	48	48	49	50	51, 52	53	54	55

material and sealant is classified by a unified soil classification system.

The Federal Housing Administration has carefully considered all current major soil classification systems and has selected the well-known unified soil classification system developed by Cassagrande at Harvard and expanded by the Army Corps of Engineers at the Vicksburg, Miss., Waterways Experiment Station.

FHA needs with respect to soil classification are twofold; *(a)* to establish a uniform means of communication between engineers, and *(b)* to provide means of identification and generalized appraisal of soils at residential building sites.

The Unified Soil Classification System (Table 1) is based primarily on grain-size or texture and plasticity characteristics in the remolded state. The system was devised principally to classify disturbed soils; therefore, its usefulness is somewhat limited when applied to natural or undisturbed soils. Realizing this deficiency, the FHA is utilizing to the fullest extent possible the agricultural soil surveys and maps prepared by the U.S. Department of Agriculture, even those prepared many years ago. Since it is impractical to acquaint engineers with the complexity of the agricultural system of classification and terminology, it was reasoned that a more simple means of identification was necessary as a basic system. This could then be supplemented and implemented by applicable parts of other classification systems. Then valuable engineering data often hidden in reports and maps of the agricultural soil surveys could be correlated and interpreted through the groups of the Unified Classification System.

In order to accomplish this for the FHA, a contract was entered into with the engineering experiment station at Virginia Polytechnic Institute to develop and amplify this classification system. Emphasis was placed on specific needs of FHA engineers, particularly those of its sanitary engineering section, as well as structural and architectural groups.

Accordingly, under the direction of Prof. Morris, head of the civil engineering department, this work was done by J. H. Hunter, formerly of VPI, as associate professor of civil engineering. It included the preparation of two rating

. . . Engineering Use of Soil Surveys

TABLE 3 Undisturbed soils at residential building sites

tables, one for undisturbed and one for disturbed soils at residential building sites (Tables 2 and 3). Each of these tables includes individual column ratings for each of the 15 groups of the unified system, for applicable engineering uses.

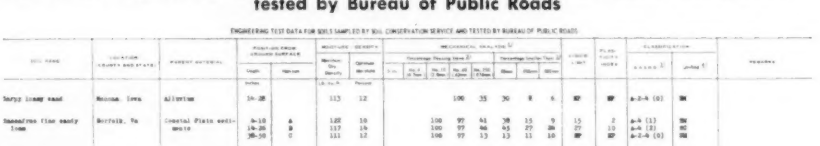
The range in soil engineering properties in the undisturbed state in any of the groups of the Unified Classification System may be wide, depending on underlying soil forming materials, density, moisture content and consistency. This particular system does not take into account or feature undisturbed or natural soil conditions. This important and significant weakness of this system has been counterbalanced, for FHA use, to some extent by the processing and use of soil engineering data derived from agricultural soil series and types. This will be discussed at length elsewhere in this paper.

Soils in the disturbed state, classified in this system, may have varying characteristics, but these can be measured and evaluated at least in a general way so as to provide a valuable guide for their engineering use. While classification in this system does not provide sufficient information for design purposes, it will give the engineer a good indication of the behavior to be expected of a soil at a given residential building site.

The Division of Physical Research, U. S. Bureau of Public Roads, has been making engineering tests of soils for a number of years. This work is being done in cooperation with the Soil Conservation Service (USDA) and the various state experiment stations. Soil samples are selected from areas or counties that have been mapped in detail. These samples of representative soil series and types are thoroughly tested by layers for grain-size, Atterburg limits and each layer is classified into groups or units of both the American Association of State Highway Officials and the Unified Soil Classification System. This work has been done for many years so that adequate engineering interpretation could be included in the individual soil survey reports. A compilation and consolidation of these test data has been made by the Bureau of Public Roads, as requested by the FHA. These data have been arranged by soil series and types in alphabetical order and are included as an integral part of a soils manual being printed by the FHA combining the amplification of the Unified Soil Classification System, as prepared by the Virginia Polytechnic Institute. A typical example of these test data (copy of engineering test data by soil series) is shown (Table 4). The FHA believes this manual will be useful in providing a workable bridge of understanding and practical use between a simple, sound engineering classification and a valuable, complex and widespread agricultural soil classification.

It is fully realized that there are many serious limitations to this approach. It can be successful only if (1) the soils sampled and tested are representative of the soil series as mapped and correlated on a national basis and (2) sufficient training is given key engineers, not only in the identification of the unified classification groups, but to properly use and interpret the information contained in the soil survey reports.

TABLE 4 Engineering test data for soils sampled by Soil Conservation Service and tested by Bureau of Public Roads



FHA engineers and technicians fully realize the advantages and usefulness of soil data contained in the soil surveys, but sometimes get bogged down in complex terminology and description. It is believed that once the engineer is able to correlate the unified classification characteristics with pretested agricultural soils, he can then project this knowledge to other soils unmapped and untested and thus do a more efficient job of appraising and evaluating soil characteristics for engineering purposes.

Summary

The Federal Housing Administration has used National Soil Survey reports and maps for a number of years. The use of these reports is now being expanded and supplemented by the development and expansion of the Unified Soil Classification System. Engineering interpretation of the various horizons or layers, as mapped by the National Soil Survey, is being made through the Unified Classification System. It is believed that the use of the unified system as a code or key will enable engineers to utilize valuable soil data that have heretofore been obscured. A method utilizing national soil surveys by interpretation and correlation with a popular engineering classification is presented.

References

Engineering soil classification for residential developments — J. H. Hunter, Virginia Engineering Experiment Station, Blacksburg, Virginia. Prepared for the Federal Housing Administration. 1959

Waterways Experiment Station. Unified soil classification system. 3 fols., Corps of Engineers, U. S. Army, Tech. Memo. 3-357. Prepared for Office of Chief of Engineers, Vicksburg, Mississippi. 1953

. . . Storage of Shelled Corn

(Continued from page 298)

The rate of corn feeding in this trial was much higher than necessary in farm practice for feeding heifers. Limited hay and extra corn was fed so as to obtain a better test of the nutritive value of the corn. With the heavy corn-feeding rates used, some of the heifers were off-feed a few times.

The growth response obtained from heifers does not indicate that the feeding value of high-moisture shelled corn is superior to regular ground corn.

In the feeding trial with milking cows, 27 Holstein and Brown Swiss cows were fed rations with the three kinds of high-moisture corn. Each group of cows was fed one kind of corn for seven weeks and then switched to another kind so that all cows were fed all kinds of corn during the three experimental periods. The first two weeks of each period was used as a preliminary or adjustment period and the last five weeks as the test or experimental period. In addition to one kind of high-moisture corn, the cows were fed corn, sorghum and oats silages, six pounds of hay per day, and two pounds of soybean meal-mineral mixture.

The results of the feeding trial with milking cows are shown in Table 7.

Based on the results of feeding high-moisture corn to milking cows for 14 weeks, there is no evidence to indicate that the feeding value of the dry matter is significantly different between rations.

From the results obtained thus far, it appears that dairy cattle make efficient use of high-moisture corn, but it is not superior to regular corn. Factors other than feeding value, such as harvesting losses and cost of storage, would determine the method of harvesting, storing, and feeding corn for dairy cattle.

TABLE 7. SUMMARY OF RESULTS OF FEEDING HIGH-MOISTURE CORN TO MILKING COWS (10 WEEKS)

Item Kind of corn (percent moisture)	Group I 25	Group II 30	Group III 35
Daily feed intake, pound			
Silage	54.0	55.2	52.1
Hay	5.8	5.9	5.9
Corn	11.6	12.8	13.3
SOM	1.9	2.0	2.0
Daily dry matter intake			
Silage	14.9	14.8	14.3
Hay	5.3	5.4	5.4
Corn	9.0	9.4	8.9
SOM	1.7	1.8	1.8
Total	30.9	31.4	30.4
Daily production			
Milk, 4 percent	33.5	33.6	33.1
Body weight changes			
Average per day	—0.7	—0.5	0.0
Feed efficiency			
Roughage dry matter per 100 lbs live weight	1.65	1.59	1.60
Grain dry matter per pound FCM	.32	.33	.32
Total dry matter per pound FCM	.92	.93	.92

Summary

Controlled feeding tests on sheep, beef and dairy animals show that feeding value of high-moisture shelled corn silage is equal to dry corn. This was true of corn with moisture contents up to 30 percent. At 35 percent moisture the performance of swine was not as good as on dry corn.

Field losses were least at 30 percent kernel moisture at harvest. Harvesting and unloading equipment performed well at this moisture.

Storage losses amounted to only 3 percent (energy loss). Discoloration of the corn occurred on top when only one inch a day was removed but animals did not refuse it and performed well on it.

Youth Farm Magazine Features Agricultural Engineering

OVER one-third million farm youth will have an opportunity to learn more about agricultural engineering through the medium of the April issue of The American FARM YOUTH magazine. In featuring agricultural engineering, the issue contained an appropriate editorial, and specially prepared articles by Roy Bainer, past president of ASAE, and J. L. Butt, executive secretary of ASAE. In addition a colorful cover entitled "Farm Progress Is Engineered" portrays engineering applications on the farm. A 4-page illustrated story titled "Engineering in Agriculture," by Roy Bainer, vividly depicts a challenging future for engineering-minded farm youth.

"What Is Agricultural Engineering?" is the title of an article, written by J. L. Butt, that presents a story of agricultural engineering in a manner in which farm youth can best understand the aptitudes, qualifications, and training necessary for obtaining a career in agricultural engineering. A specially prepared "aptitude score sheet" is included, to assist students in determining their possible interest in agricultural engineering.

Eight-page reprints containing both articles and several letters commenting on the issue are available from the American Farm Youth Publishing Co., 113 West Main St., Danville, Ill., at 5¢ per copy in quantities less than 500. Quotations on larger quantities may be obtained by writing to Harold O'Connor, Editor, American Farm Youth magazine.

. . . Life Sciences and Engineering

(Continued from page 289)

part in the physical world. This is simply because of the variability of living things. Remember that the biochemist must deal with living things, which at times are not at all cooperative. Although biochemistry started as an applied science, it has acquired a place among the pure sciences.

Biophysics is another discipline that lies on the borderline between the biological and physical sciences. In fact, at some schools, it is found in departments of physics, which are often in schools of engineering; while at others it is found in departments of biology, which are frequently in schools of agriculture. In public and industrial laboratories, the same variations occur. Broadly speaking, biophysics is the physics of living organisms as contrasted with the classical physics of inanimate things. In practical terms, biophysics is that specialty which deals with those aspects of organisms that require a specialist's competence in contemporary physics. Certainly the biophysicist must be competent in both physics and biology. Biophysics is concerned with the organization and activities of living matter in relation to space, time, and mass-energy. Thus it is complementary to biochemistry, which deals with the atomic and molecular composition of living things and with the changes in composition associated with activity. There is, therefore, considerable overlap between biophysics and biochemistry. But is not the same thing true for the physics and chemistry of inanimate materials? The processes that take place in living things are based on molecular change, and the chemistry of the molecules is affected by the physics of the atoms (Hill, 1956).

I would like now to call attention to the field of endeavor known as bioengineering. It is defined as the field of applied science concerned with the application of physical science techniques to problems in biology. I call your attention specifically to the article, entitled "Instrumentation for Bioengineering" in the May 3, 1957, issue of *Science* (Frank, 1957), which treats of one division of this field — instrumentation development. In this particular area alone, there is a wide range of the physical sciences that are being applied to biological problems. One example given in the reference cited is the problem of measuring the pressure inside the eye, which is of special significance in detecting glaucoma. You can readily imagine the difficulties encountered in developing precise instrumentation for this task. You know also that many studies have been made of motion and of energy expenditures by animals and man. Special devices are necessary to record all the factors and variables that must be considered in these studies. One of the ultimate objectives of the vast amount of research being done on space flight is to get man into space. The delicacy and precision of the instruments needed to study effects of space flight on living things staggers the imagination. The biologist cannot simply say to the physical scientist or engineer, "Design me an instrument to measure this variable," and expect to be provided with the instrument he needs unless the engineer understands and appreciates the problem of the biologist. And the biologist must also have some understanding and appreciation of the engineer's problems as he attempts to develop instrumentation. The relationship here is more than one science simply servicing another. The engineer is more than craftsman. He must be an equal partner with a full appreciation of the biological problem.

Let us take another specific example which I think illustrates the interrelation of the biological and physical sciences — one that calls for the intellect of a practicing biologist and that of a practicing physical scientist. Biologists have for years been interested in storing biological materials such as germ plasm, tissues, and parts of organs or whole organs for use at later dates. Think of the possibilities, for example, if one could store indefinitely the germ plasm of a great sire or parts for the repair of damaged bodies. Great progress has been made through the process of freezing. This has become possible as the nature of the process has been understood. The mechanism of freezing of biological material is explained in terms of simple and consistent physical phenomena. It appears that all the biochemical, anatomical and physiological sequelae of freezing are directly or indirectly the consequence of the single physical event, which is nothing more than the removal of pure water from solution and its isolation into biologically inert foreign bodies, ice crystals (Meryman, 1956). Problems of the kinds associated with the preservation of biological material calls for the intellect of more than one kind of specialist.

Perhaps it is time we turned to the general interrelation existing between agricultural engineering and the life sciences. As already pointed out, a large part of your sphere of work, being allied with agriculture, is closely related to the life sciences. Perhaps you would even accept me as one of you if I were to say that, as a former practicing biologist, I was a biological engineer. I certainly applied the fundamentals of the biological sciences, just as you apply the fundamentals of the physical sciences.

I was much interested in the article, entitled "Engineering in Agriculture" by your former ASAE president (McKibben, 1959). I was surprised to read that it is necessary at times to explain the term "agricultural engineering." I agree with him that the great majority of farm problems involve engineering application to some extent. I don't know what the exact percentage is, but I do know that these problems bring you in direct or indirect contact with the life processes. I believe that in some of these you must have a rather fine appreciation and understanding of the biological processes involved if you expect to contribute to the solution of the problem.

Agricultural engineering in a broad sense includes those phases and features of the science and practice of engineering identified with and related to agriculture. The intricate relationships of soil fertility, water, and crop production under modern farming conditions involve many phases of engineering. You cannot escape, even if you wished, the world of living things.

I was much interested in Dean Marsten's (1953) comments and questions about the activities of an agricultural engineer. He said that agricultural engineering has not demonstrated a need for or produced superior scientific knowledge. He said that agricultural engineering has not had to go to basic scientific research and to push back the boundaries of knowledge to find the tools for its problems. I am not capable of passing upon the merits of these judgments, nor even to speculate on the professional status of the field. Certainly there is no branch of engineering which covers such a broad field as does agricultural engineering. Perhaps this is the basis of criticism. I do know, however, that no engineer can be faced with more baffling problems than the agricultural engineer. This may not be the case in a purely engineering problem. But when one thinks of the broad contact the agricultural engineer has with the living world, and of the complexity of the living world, then one has some insight into intricate problems that can concern him. I am not competent, and perhaps no one is, to determine whether the agricultural engineer has not needed to go back to fundamentals, especially where his problem and that of the biologist (agriculturist) merge. I am inclined to think that the agricultural engineer, because of his association with the life sciences, has an unlimited opportunity for the development of fundamental, as well as practical, knowledge. To do this, he need not become a life scientist as well as an engineer. A basic understanding and appreciation would be necessary, however. This, coupled with cooperative efforts with a life scientist who has the necessary counter-understanding and appreciation, could result in marked advancements.

Agricultural engineering is divided, perhaps arbitrarily, into four general areas — soil and water conservation, farm structures, farm power and machinery, and rural electrification and processing. In some of these areas, the life sciences are most certainly involved because the engineering practice involved serves, in the final analysis, a living thing.

Consider the soil for a moment. It is far more than an inert conglomeration of organic and inorganic matter. It is, in fact, a wonderful living world.

These soil inhabitants are specialists. Some rot organic matter; others transform nitrogen; many are producers of antibiotics and a few are enemies, since they cause either plant or animal diseases. These creatures of the soil range from the invisible bacteria through the actinomycetes, fungi, algae, protozoa, to the nematodes and earthworms. The beneficial effects of many of the soil microorganisms have been well known for a long time. The harmful effects of certain of them, the disease producers, have also been known for many years. And more is being learned each day, since we are more concerned about our enemies than our friends. Of what concern is this to an agricultural engineer? There are many basic questions to be answered in a study of a soil-borne disease. Generally, somewhere in an investigation comes the question: What is the relation of the parasite to its soil environment, and to what extent can the soil be managed to destroy the disease producer?

It seems to me that, as soon as we mention soil management, the agricultural en-

gineer is involved along with the agronomist, plant pathologist, and others. The engineer is concerned with water and equipment, all of which affect the soil environment. Soil moisture, soil temperature, organic residues and tillage methods form a part of or exert an influence on the soil environment. Some of the things that concern agricultural engineers, such as irrigation and tillage, do have a direct bearing on the ecological relationships in the soil environment. This is to me, at least, demonstrative of a direct relation between the life and the engineering sciences. I refer to more than just cooperation. I am talking about a true understanding and some knowledge on the part of the biologist and the engineer of the other's field. Let me cite a few examples.

Disease-producing microorganisms spread in many ways. Some of them are spread by streams of water that pick up the organisms in one way or another. These same streams may be the ones you want to use for irrigation purposes, and, if so used, will be the source of infection for new areas. Your possible use of these streams depends upon the nature of the organism, the nature of the crop or plants to receive the water, the time of the year, and other factors. It is not the engineering problem here that determines the issue, it is the life science problem.

Disease-producing microorganisms are spread by farm machinery, generally in the soil that adheres to it as it moves from field to field or farm to farm. This is a serious problem. The answer is easy: clean the equipment. But now we face the problem of defining cleanliness. What may be clean to the engineer is filthy to the biologist. Remember, the biologist is dealing with a very tiny, even a microscopic living thing, and only the smallest bit of soil represents a source of danger. So, when the biologist asks the engineer to design equipment that can be cleaned and sterilized easily he is speaking in his own terms. You must know what the biologist means and have an understanding of what he is attempting to accomplish. This calls for some knowledge, at least, of the living world.

While we are on the general area of farm machinery, I wish to refer briefly to a recent article dealing with the pelleting of hay (Butler and McColly, 1959). The article reported studies on the development of a machine for this purpose. The introduction stated the desirability of pelleting hay in the interest of efficiency, transportation, and storage. No reference was made to the fact that pelleted hay had the same or higher nutritive value. The non-agricultural biologist would immediately wonder what the cow thought of the pellets — and she tells us by the way she responds in gains or milk production. I am making a mountain from an ant hill. My purpose is to emphasize that we, as appliers of science, must keep in mind the end to which we make our applications.

The preceding examples have indicated some of the relationships between the agricultural engineer's work and the life sciences. The field of farm structures is no less related. Farm structures vary all the way from a simple open shed to buildings that house the most complicated machinery known — a living thing. Not to consider the occupant in the design of a farm structure is to ignore its purpose.

We keep animals and plants, for the most part, for the service we want from them. We expect them to produce economically and efficiently. We cannot get efficient production or performance if we fail to provide the environment that will best serve the plant or animal.

A real understanding of living things must include much knowledge of the effects of the environment on plants and animals. Two approaches are used to reach this understanding: field observations and laboratory experiments. Field observations are not ideal, and laboratory experiments are often quite restrictive in range. In between these two approaches are laboratory facilities in which the whole range of climatic variables may be controlled individually. Controlled-climate facilities for biologists are now receiving much attention. One or two major ones, costing considerable money, have been built and their versatility is enabling the biologist to probe deep into many problems formerly unaccessible. There is still need for simpler but equally versatile climatic chambers so that their use can become more general. The engineering problems involved have not all been solved. An engineer with a feeling for the life sciences might make significant contributions in this field.

I wish to refer to the series of articles under the title "Environmental Relationships of Plants and Animals," which appeared in the September, 1959, issue of AGRICULTURAL ENGINEERING. They were good summaries, but, as the foreword pointed out, there is a great deal of literature not covered by these articles. I commend them to you because they give you considerable insight into what the biologists, especially those concerned with crops and farm animals, have been trying to do. The foreword also stated that only recently have engineers, to any extent, taken an active interest in this field. I hope this interest grows.

Let me briefly point out two examples: You are aware of the efficiency now possible in the poultry industry, especially in broiler production and, to a lesser degree, in laying flocks. The reasons are many, and they include better strains of birds (the result of genetic studies), better nutrition (the result of biochemistry and nutrition), better disease control (the result of research in veterinary science), and better housing and equipment. The housing and equipment is designed and being improved with one thing in mind — the best environment for the bird.

Compared to the poultry industry, swine production is far less efficient. It is true that progress is being made in genetic studies, nutritional improvements, and disease control. But little critical work has been done on environmental control, i.e., housing. I venture to say that, until some good studies are done and improvements are made, the pig will still not be very efficient in feed utilization. Maybe the pig will never be as efficient as the chicken — but we ought to find out. This task calls for the assistance of some good engineering brains. And I mean more than just building something the biologist might suggest, but the kind of assistance that comes with an understanding of the fundamental nature of the living thing, in this case, the pig.

Sheepmen have been plagued with the problem of summer sterility or seasonal breeding. This frequently results in lower lamb crops or lamb crops badly timed for future markets. Some good work has been done, but I am not sure that all agree on the cause of this phenomenon. Some consider the major factor to be the amount of light. Perhaps the temperature plays a part. Or, could it be a combination of these and other factors? A bioclimatic chamber would give the biologist a means for answering the question. Once answered, the question of how to apply the answer to practical conditions remains. We need here an engineer who is also interested in sheep.

It is possible to extend the list of examples to the point of boredom. These simple, practical ones, however, serve to illustrate what, to me, represents an area in which engineers can take an active part.

I hope I have presented evidence of a true relation between the life sciences and engineering. There will be many, no doubt, who will not accept my argument as valid. Be that as it may, I think that we can agree that there may be need for more communication between persons in the two areas. We can also agree that the agricultural engineer has a great opportunity in doing just this. This is especially true of those who work in colleges and universities. I am sure that the biologist in the schools of agriculture would welcome the chance to put to work the interrelations that exist between the life sciences as they are incorporated in agriculture, and the engineering sciences as they are developed in agricultural engineering.

I'd like to close with an excerpt from a paper by Dr. Vannevar Bush, entitled "Professional Collaboration" (1957): "In the first place, let us record that there are individual members of every profession who will never collaborate with anyone under any circumstance. Let them depart in peace; their day is nearly done," and "The man of genius still is the most important element in the whole array, and upon his excellence most of progress depends, but if he does not know how to collaborate or is too selfish or timid to do so, we can safely forget him."

References

Bush, V. 1957. Professional collaboration. *Science*, 125. 49.

Butler, J. L. and McColly, H. F. 1959. Factors affecting the pelleting of hay. AGRICULTURAL ENGINEERING, 40. 442.

Everitt, W. L. 1959. New tools for new engineers. *Jour. Engr. Educ.* 50 (2), 103.

Frank, W. E. 1957. Instrumentation for bioengineering. *Science*, 125. 871.

Gerard, R. W. 1957. Units and concepts of biology. *Science*, 125. 429.

Hill, A. V. 1956. Why biophysics? *Science*, 124. 1233.

Marston, G. A. 1953. Integrating activities of an agricultural engineering department. *Jour. Engr. Educ.* 43 (10), 570.

McKibben, E. G. 1959. Engineering in agriculture. AGRICULTURAL ENGINEERING, 40. 385.

Meryman, H. T. 1956. Mechanics of freezing in living cells and tissues. *Science*, 124. 515.

Weaver, W. 1957. Science and the citizen. *Science*, 126, 1225.

Zacharias, J. R. 1957. Structure of physical science. *Science*, 125. 427.

ASAE Past-President Honored

Roy Bainer, ASAE Fellow and past-president of ASAE, was one of three Kansas State University alumni to receive Distinguished Service Awards in the field of Engineering and Architecture on March 18 during the University's annual Engineers' Open House Week. A 1926 KSU graduate in agricultural engineering, Roy has been a member of the University of California staff since 1929 and at present is chairman of the agricultural engineering department and assistant dean of engineering. In 1945, he was consultant to the British Ministry of Agriculture and a consultant to the Army of Occupation in Japan in 1948. In 1958 he was a co-director of the Mechanization Center sponsored by the Food and Agriculture Organization of the United Nations. He received the Cyrus Hall McCormick Medal in 1948 and is also a Fellow in the American Association for the Advancement of Science. He was president of ASAE in 1956-57.

Roy Bainer

The Awards presentation was made by KSU President James A. McCain and the address to the assembly was made by Col. John P. Stapp, who spoke on the problems of manned space flight. Also honored were KSU alumni W. V. Buck and T. R. Griest.

Chemical and Fertilizer Committees Merge

The ASAE Agricultural Chemical Application Committee and the Committee on Fertilizer Application on March 1 approved a merger of the two committees in an effort to further the progress of the Society's contribution to agricultural chemicals and fertilizers. Earlier action merged the ASAE Agricultural Aviation Committee to strengthen and broaden its scope and activities.

According to M. L. Adams, Chairman of ACAC, the 30 members of the combined committees represent a cross section of recognized specialists from colleges, universities, U. S. Department of Agriculture, equipment and chemical industries. Work is being concentrated on objectives which coordinate and exchange information involving standardization, program planning and publicity, problems in pesticides, fertilizers, aviation, and setting up an occupational file. The Committee has sponsored and assisted with half-day program sessions devoted to agricultural chemicals at both the most recent Annual and Winter ASAE meetings and emphasis is being placed on committee meetings to encourage participation from agricultural industries. For those interested, an Agricultural Chemical Application Committee brochure is now available at ASAE Headquarters.

Engineers, Scientists and Architects Day

Engineers, Scientists and Architects Day was held on February 25 at the Presidential Arms, Washington, D.C., and was sponsored by the D. C. Council of Engineering and Architectural Societies, the Washington Academy of Sciences, and Joint Board on Science Education, comprising some 60 organizations.

The morning program was devoted to a symposium on the great challenge of the 1960's to engineers, scientists and architects – space. At the luncheon meeting, National Capital Awards were made to the outstanding young engineer, applied scientist, and architect. Citations were also presented to 26 nominees for professional awards and 87 for science teachers awards. James A. Van Allen, physics department, Iowa State University, was the luncheon speaker, his subject being "Radiation Environment of the Earth."

Of the 750 in attendance, the following 23 members of the ASAE Washington, D.C. Section participated: J. P. Schaenzer, group chairman; L. E. Holman, J. W. Rockey, W. M. Carleton, L. A. Liljedahl, M. S. Timmins, Jr., M. C. Ahrens, Hajime Ota, J. R. Dodge, P. E. Strickler; L. E. Campbell, treasurer of ES and A Day Executive Board, District of Columbia Council; P. N. Winn, Jr., P. E. James, G. C. Winter, E. G. McKibben, K. H. Norris, A. A. Stone, R. L. Green, B. C. Reynolds, S. P. Lyle, Francis Scofield, R. W. Parker, and Wallace Ashby.

ASAE Committee Merger

M. L. Adams, *(left)* chairman of Agricultural Chemical Application Committee, and J. W. Ackley, chairman, Committee on Fertilizer Application, respond in behalf of both committees, who on March 1 approved the combining of their efforts to further the progress of ASAE contribution to agricultural chemicals and fertilizers

On April 6 the Southern Association of Agricultural Engineering and Vocational Agriculture, G. E. Henderson, coordinator, was awarded the Certificate of Commendation by the National Safety Council for its publication "Tractor Operation and Daily Care." Receiving the award is T. G. Walter, *(left)* president of the Association, from James Messerschmitt of the National Safety Council. The publication is the first of its type to receive an award for farm safety; and the award is the first of its type to be given to a regional association

EJC Elects Vice-President

George E. Holbrook, a vice-president, director and executive committee member of E. I. du Pont de Nemours & Co., has been elected vice-president of Engineers Joint Council. He succeeds Cecil Boling, who has resigned. He received an M.S. degree in 1932 and a Ph.D. degree in 1933 in chemical engineering from the University of Michigan. Since joining du Pont in 1933, he has held many posts of responsibility previous to his present position, which he attained in 1958. He is also a director of du Pont Company (United Kingdom) Ltd., London, and du Pont of Canada Ltd. He has served as a member of EJC's board of directors, executive committee and planning committee.

Agricultural Meteorology Conference

The third Agricultural Meteorology Conference will be held May 18-19 in Room 302 of the Federal Office Building, Kansas City, Mo. Program arrangements have been made through the cooperation of the Committee on Agricultural Meteorology and the Kansas City Seminar of the American Meteorological Society, with the support of the American Society of Agricultural Engineers; American Society of Agronomy; American Phytopathological Society; Entomological Society of America; Society of American Foresters; American Society of Horticultural Science; and American Statistical Association. The Wednesday morning session will consist of a panel discussion on forecasting and climatological services to agriculture. The theme of the afternoon session will be agricultural meteorology. Thursday morning will be devoted to bioclimatology, and the concluding session on Thursday afternoon will cover the topic of energy and vapor exchange between plants and atmosphere.

K. W. Anderson

Charles S. Morrison

Edwin Paul

Ralph Morr

K. W. Anderson has accepted a new assignment for Deere and Company and is now headquartered in Paris, where he is organizing a product research operation for Compagnie Francaise John Deere. He was formerly with the company's Moline, Ill., plant as manager of product research.

Charles S. Morrison has been promoted to manager of product research for Deere & Co., Moline, Ill. He joined the company in 1947 as a member of the product development department and was named head of the department in 1951.

Edwin Paul recently has been promoted to chief engineer of the Agricultural Chain Division, Chain Belt Co., at Dolton, Ill. He is a graduate of the University of Massachusetts and joined the company in 1950 as junior product engineer at the Roller Chain Division, Springfield, Mass. In 1954 he became field engineer and then product engineer in 1957.

Ralph Morr has received new responsibilities at New Idea Farm Equipment Co., Coldwater, Ohio, where he is a product engineer. In addition to his duties on mowers and rakes he will also be responsible for design programs on fertilizer and lime spreaders. He has been with the company since 1951.

NECROLOGY

Lewis A. Jones, a Life Fellow of ASAE and former head of drainage investigations for the Soil Conservation Service, USDA, died on March 24 in Washington, D. C., at the age of 74. His sudden death was attributed to a heart attack, which he suffered while waiting at the Municipal Center for his District driver's permit.

Lewis A. Jones

A native of St. James, Minn., he was graduated from the Worthington, Minn., high school and received a degree in civil engineering from the University of Minnesota in 1907. His professional work included: Assistant city engineer, Mitchell, S. D., 1907; surveyor, U. S. Indian Service, 1908; assistant engineer, Great Northern Railroad, 1908-1909. In 1909 he was appointed assistant engineer with the former Office of Experiment Stations, USDA, which later was transferred to the Bureau of Public Roads. Mr. Jones was author of numerous old drainage surveys, many of which are of current value. He worked for the department on drainage and allied projects in Kansas, Texas, Arkansas, Idaho, and several southeastern states.

Mr. Jones joined the United States Army as an engineer captain in 1917 and served overseas for more than a year. Shortly after returning from the Army he was called to Washington and from 1919 to 1931 he served as assistant to the head of the agricultural engineering division of the Bureau of Public Roads. He was appointed chief of the drainage division in 1931, when the Bureau of Agricultural Engineering was formed and continued this work with outstanding success. In 1939, this work was transferred to the Soil Conservation Service and Mr. Jones was made head of the division of drainage and water control, which included research work in the fields of hydrology, sedimentation, and hydraulics in addition to agricultural drainage. One of his outstanding accomplishments was the development of a plan for drainage and water control of the Florida Everglades region. The work, which he directed, established basic standards in the fields of drainage, hydrology and hydraulics, many of which are in current use. He retired in 1952 and since then has spent much time on building activities of the Takoma Park Baptist Church.

He was a life member of the American Society of Civil Engineers, and held memberships in the American Geophysical Union and the Soil Conservation Society of America, Masonic Lodge #29 of Takoma Park, and Beta Theta Pi Fraternity. He was elected as a Councilor of ASAE from 1930 to 1932. His wife, Pearl, and a daughter, Mrs. Ira D. Porterfield, survive.

Carl D. Gross, an ASAE member since 1924, died suddenly on March 13 at his home in Springfield, Ill., at the age of 57. He had been in the consulting business as a farm management engineering consultant since 1958, and prior to that time had been an engineer with the Illinois State Health Department. He earned a B.S. degree in agricultural engineering in 1923 from Kansas State University, and in 1925 received his M.S. degree from Iowa State University. He also earned an M.S. degree in municipal and sanitary engineering from Harvard University in 1929. He was a member of St. Paul's Lodge 500, A.F. & A.M .; Ansar Temple; American Public Health Assn.; Central States Sewage and Industrial Wastes Assn.; Federation of Sewage and Industrial Wastes Assn.; Conference of State Sanitary Engineers; Phi Kappa Phi; Delta Omego; Chicago Harvard Club; Kansas Farm Bureau; and the Illinois Professional Engineers. He is survived by a daughter, Susan, and a son, David.

John A. Slipher, retired extension soil conservationist of Ohio State University, has been made the first chairman of the newly organized Ohio Water Commission. The new group is a part of the Ohio Department of Natural Resources and has the task of coordinating the water programs in and of the state, developing water supply flood control and flood-plain zoning programs for all areas of the state, and obtaining the most beneficial use of water resources.

Alfred A. Pfingsten, farm sales supervisor for Wisconsin Public Service Corp., Green Bay, retired on May 1. He supplied leadership in the company's farm program for the past 34 years, and is known to many as one of the real pioneers in rural electrification, having been engaged in such work in various capacities over the past 42 years.

Joseph T. Chester and **Richard A. Kummerer** have recently become co-owners of the firm, Drives, Inc., in Fulton, Ill., which handles steel detachable chains. Mr. Chester is president and sales manager and Mr. Kummerer is vice-president and secretary-treasurer. Both men were formerly associated with the Agricultural Chain Division, Chain Belt Co.

Jack G. Lamb advises that he is now located in Decatur, Ga., where he is sales engineer for Economy Forms Corp. He previously was district sales representative for Irrigation Equipment Co.

E. J. McFadden, who has been an agricultural engineer with the Tobacco Research Board of Southern Rhodesia, has accepted the position of engineering consultant and director to Vali Brick Co. (Pvt) Ltd. and Dale Face Brick Co. (Pvt) Ltd. in Salisbury, Southern Rhodesia, Africa.

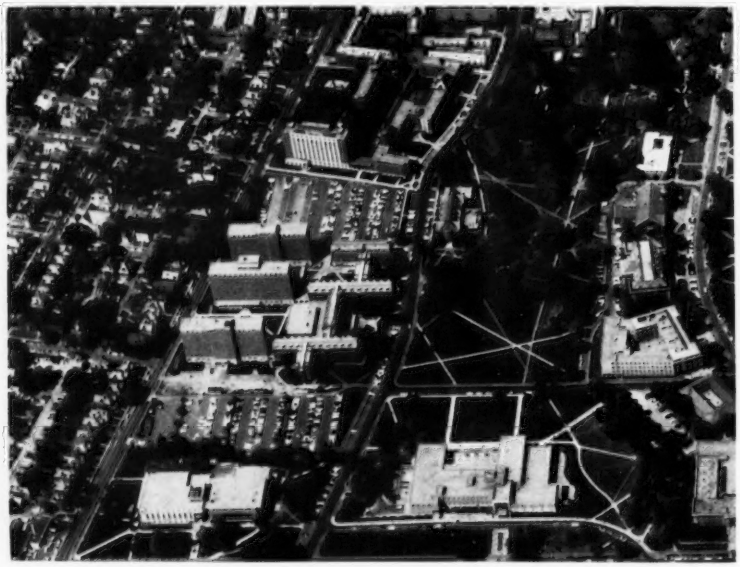
Wendell Moore advises that he has accepted the position of agricultural fieldman with Douglas Fir Plywood Association in Des Moines, Iowa. He formerly was connected with Opekasit, Inc. of Lebanon, Ohio, as an agricultural engineer.

Paul Jacobs has been transferred from John Deere Tractor Research and Engineering Center, Waterloo, Iowa, to the John Deere Dubuque Tractor Works in Dubuque, Iowa.

Ernest G. Krause, formerly agricultural engineer, with the Bureau of Indian Affairs at Lapwai, Idaho, advises he is now located in Nespelem, Wash., at the Colville Indian Agency.

Seward H. Foote recently has been appointed special assistant to the master of The National Grange in Washington, D. C. He will be primarily responsible for an expanded Grange program and will head-up such a program on a nation-wide basis in the near future. He formerly was executive vice-president of American Campaign Services of Kansas City, Mo.

(Continued on page 335)



ASAE activities will be conveniently confined to one section of the campus. The large building in the lower right foreground is the Ohio Student Union Building and will serve as ASAE headquarters. To the left of the Union is the Law Building, where several technical sessions will be held. Behind the Law Building are the new eleven-story dormitories, Smith and Park Halls, which are the housing headquarters. The parking lot for ASAE visitors is near the center of the picture

OHIO STATE UNIVERSITY Hosts 53rd Annual ASAE Meeting June 12-15

THE 53rd Annual Meeting of ASAE will be held June 12 to 15 at Ohio State University campus in Columbus. In addition to the technical programs, Ohio Section members have planned a daily series of entertainment and tours. Wives and children will also be entertained with special programs and tours during the four-day stay.

Among the highlights of the program will be a Sunday evening opening buffet dinner and entertainment; the Monday evening beef barbecue dinner on the Ohio Union lawn, followed by square dancing at the Ohio Union ballrooms; the tours scheduled for Tuesday afternoon; the FEI student dinner on Tuesday evening; also on Tuesday evening the family swim time at the Natatorium, and the ASAE bowling tournament; the Annual Banquet and presentation of Awards on Wednesday evening; and the Open House at the Ohio Agricultural Experiment Station, Wooster, on Thursday.

Ives Hall, agricultural engineering department, will be headquarters for some exhibits and general display of equipment

Advance registration cards and hotel reservation forms have been mailed to ASAE members. Non-members interested in attending the meeting should communicate with the central office of the Society at St. Joseph, Mich., for information on accommodations and the program of the meeting sessions.

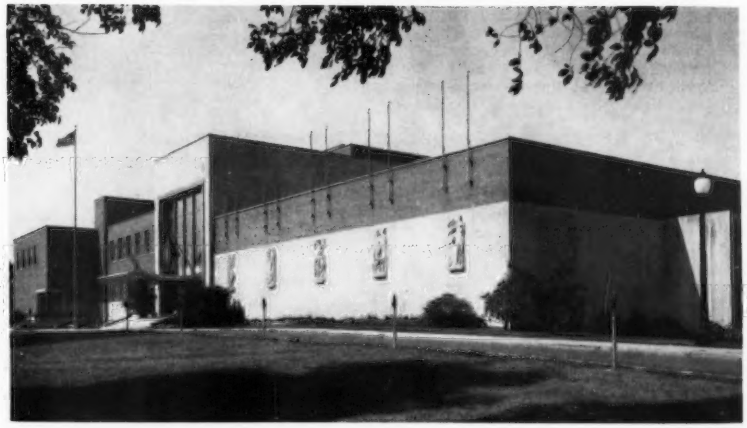
General Session

The General Session will be held Tuesday morning, June 14, at which time the winning paper in the ASAE Student Paper Award competition will be presented. The featured speaker, Murray D. Lincoln, president, Nation-

(Above) Open house will be held at the new agricultural engineering building at the Ohio Agricultural Experiment Station at Wooster, Saturday and Sunday, June 11 and 12, and on Thursday, June 16

(Right) The spacious, color-dynamics-treated shop in the new research building at Wooster is supplemented with many smaller laboratories with specialized equipment such as a climate control room

ASAE HEADQUARTERS



(Left) The Ohio Student Union Building will serve as headquarters for the 53rd Annual Meeting of ASAE

(Below) The beautiful Terrace Lounge of the Ohio Student Union Building will serve as headquarters for ladies' activities

wide Insurance Companies, Columbus, Ohio, will give his address on the new look in agriculture, following the paper presentation. Also a highlight of this session will be the president's address entitled "Extending Our Horizons," by ASAE President L. H. Skromme, chief engineer, New Holland, Pa. The Annual Business Meeting of the Society will conclude this session.

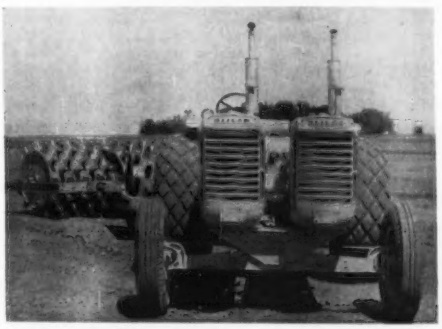
Technical Sessions

The Power and Machinery Division will hold seven concurrent sessions during the four-day meeting period, plus one joint session with the American Grassland Council. The Soil and Water Division will hold four sessions, and the Electric Power and Processing and the Farm Structures Divisions will hold four and three sessions, respectively, in addition to two joint EPP-FS sessions.

Special Programs

The Student Branches program will consist of two meetings — one each on Monday and Tuesday mornings, June 13 and 14, plus the FEI dinner for students Tuesday evening. The Extension program will be held Monday morning, June 13, beginning with a 7:00 a.m. breakfast.

The Public Land and Public Works group will hold its sessions on Thursday, June 16.



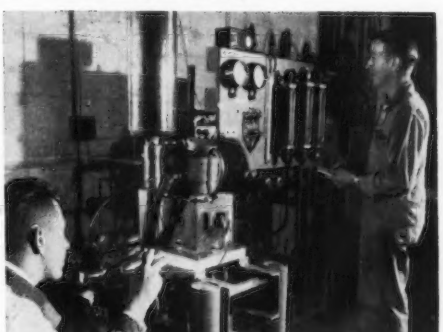
A radio-controlled, twin-engine production model tractor will be exhibited during the meeting

American Grassland Council

The annual meeting of the American Grassland Council will be held June 14 to 16, in conjunction with the ASAE Annual Meeting. Program for the three-day meeting will include a field tour of a dairy farm, a beef farm, and the Sohio Fertilizer Plant, on Tuesday, June 14; presentation of papers on Wednesday; and an Open House at the Ohio Agricultural Experiment Station, Wooster, on Thursday. Grassland research will be featured at the Open House.

Exhibits

Extension Exhibit entries in the following specific classes will be set up on the first floor of the Ohio Union: Publications; Demonstration Models; Movies; Radio and TV; Slides and Film Strips; and Extension Methods and Recipes. The American Grassland exhibits may be viewed in the Main Lounge of the Ohio Union and the agricultural engineering exhibits may be seen in Ives Hall.



For those interested in research, the tour of Battelle Institute, largest independent research institute in the world, scheduled for Tuesday, June 14, will be a highlight. Developmental study of a free-piston engine is shown

Southwest Section

. . . and the entertainment came

Some 139 people converged on Shreveport, La., March 24-25, for the annual meeting of the Southwest Section at the Washington-Youree Hotel. Sixty-seven were members, 26 guests, 33 students, and 13 ladies. Following is a first-hand report from E. D. Wilborn, past-secretary of Southwest Section:

"An interesting sidelight of the meeting was the discovery that our efficient executive secretary, Jimmy Butt, can 'run out of soap'. Jimmy appeared on the banquet program — between the main speaker and the entertainment. At the start, he promised to talk 'until the entertainment arrives'.

"Jimmy reported on progress with the ASAE motion pictures — no entertainment. He told about operations of the headquarters office — no entertainment. He discussed the forthcoming Winter Meeting in Memphis — still no entertainment. He talked about AGRICULTURAL ENGINEERING magazine, the Yearbook, and the Transactions — no entertainment showed up. About the time he worked down to discussing the problems of dealing with the custodial staff, Jimmy 'ran out of soap'— but no entertainment was there to take over. A recess was declared.

"Seriously, Jimmy did a wonderful job of reporting on the national activities of ASAE, and he filled an important spot on the program. The entertainment for the banquet — the world-famous Centenary College Choir—finally arrived. Everyone agreed it was well worth waiting for."

At the business session, officers elected for the following year were: J. L. Gattis, chairman; E. D. Wilborn, vice-chairman; and A. J. Rhodes, secretary.

Quad City Section

The Quad City Section held a dinner meeting on March 4 at the American Legion Hall, Moline, Ill., at which papers on the problems related to the design of light industrial equipment and the role of chemicals in today's agriculture were given.

The Section also held its Annual Meeting on April 22 at the Moline American Legion Club, Moline, Ill. The afternoon session included a tour of the John Deere Harvester Works in East Moline, and a demonstration and discussion of the design and potential of the principle of the "Aeromobile," by William Bertelsen, Neponset, Ill. Following the dinner and business meeting, I. B. Jensen, sales manager, Riehl Division, American Machine and Metals, East Moline, Ill., reported on fatigue testing equipment. Lawrence H. Skromme, national ASAE president, was on hand to address the group.

Chicago Section

The Wisconsin members were hosts when the Chicago Section held its spring meeting on April 27 at the Embers Restaurant, Madison, Wis. The meeting theme was "The Contribution of Specialized Farm Machinery Manufacturers to American Agriculture" and the program featured a panel discussion. Don Huhn, chief engineer, Gehl Brothers, West Bend, Wis.; Phil Zink, senior project engr. for hay equipment, Farmhand Materials Handling Implements, Hopkins, Minn.; and Jack Conant, sales manager, Cunningham Mfg. Co., LaCrosse, Wis., participated in the discussion.

Washington, D.C. Section

The Washington, D.C. Section held a luncheon meeting on April 8 in Room 6962, South Building, USDA, Washington, D.C. The program chairman was E. G. McKibben, director, Agricultural Engineering Research Branch, USDA, Beltsville, Md. Wallace Ashby, chief, Livestock Engineering and Farm Structures Branch, AERD, USDA, Beltsville, Md., spoke on progress in farm building research.

A luncheon meeting will also be held on May 13 in the USDA South Building, at which Gladwin E. Young, deputy administrator, Soil Conservation Service, USDA, Washington, D.C., will be the featured speaker. He will speak on 25 years of progress in soil and water conservation. During the business meeting, new section officers for the coming year will be elected.

ASAE MEETINGS CALENDAR

June 1 — CONNECTICUT VALLEY SECTION, Yankee Atomic Power Plant, Rowe, Mass. and Plantation Club, Charlemont, Mass.

June 12-16—ANNUAL MEETING, Ohio State University, Columbus, Ohio.

August 22-23—NORTH ATLANTIC SECTION, University of Massachusetts, Amherst.

October 19-22 — PACIFIC NORTHWEST SECTION, Empress Hotel, Victoria, B.C., Canada.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

South Carolina Section

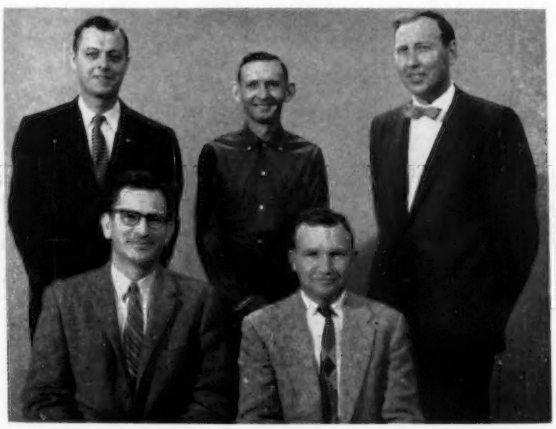
The South Carolina Section held its winter meeting at Clemson Agricultural College on March 3 and 4. Highlights of the program included discussion of poultry automation and design of peanut combine. An additional feature was the excellent talk by A. W. Cooper on his recent trip to Russia, which he illustrated with slides. To complete the meeting, the group toured the Utica-Mohawk Plant of the J. P. Stevens Co., where they saw the processing of cotton from the raw product to the finished goods, ready for shipment. Speakers and visitors from other state Sections included: A. W. Cooper, Alabama; Harry Gillespie and William Moore, Georgia; J. K. (Farmer) Jones, Tennessee; and Robert W. Wilson, North Carolina.

Connecticut Valley Section

The Connecticut Valley Section held a dinner meeting on April 13 at the Shell Chateau, Willimantic, Conn. An afternoon tour of the University of Connecticut Agricultural Engineering and Poultry Department preceded the dinner. A panel discussion on poultry environment completed the program.

The Section also will hold a dinner meeting June 1 at the Charlemont Plantation Club, in Charlemont, Mass. The meeting will be preceded by a tour of the Yankee Atomic Power Plant at Rowe, Mass., at which John Labervean of the Yankee Co. will be the speaker.

Agricultural engineers from western states conferred at the annual meeting of the Rocky Mountain Section at New Mexico State University, April 1 and 2. *Left to right,* discussing the program, are: A. S. Curry, associate director, Experiment Station, NMSU, and retiring Section chairman; L. H. Skromme, chief engineer, New Holland Machine Co., New Holland, Pa., and ASAE national president; Clarence F. Becker, head, agricultural engineering section, University of Wyoming, Laramie, and new Section chairman; and Norman Evans, head, agricultural engineering department, Colorado State University, Ft. Collins.



New officers of the South Carolina Section are: *(Seated, left to right)* Wilton Jones, chairman; Sidney Nunnery, secretary-treasurer; *(Standing, left to right)* St. Clair Knight, membership vice-chairman; Joe Cocke, program vice-chairman; and Frank Hedden, publicity vice-chairman.

It's economical to design with concrete

Sound structural design demands a proper balance between cost and service life. Durability often justifies a greater first cost. But in many cases, it's achieved at no added cost by use of proper design principles.

This is the second of a series of reports showing design techniques with concrete applied to specific parts of a building. The paragraphs that follow tell how to design low-cost, durable concrete floors and paving.

Floors and Paving . . . "to be without costs more"

"A farmer pays for a paved feedlot whether he has it or not. And if he operates without one for many years, he may pay for it several times," said a midwestern cattle feeder. In this case, as in many others, the low-cost solution—leaving the barnyard unpaved—is really the most costly in the long run.

By following the design principles outlined below, engineers can achieve true low cost and at the same time assure a long-lasting paving job.

Slab Thickness: The thickness to use depends on the magnitude and frequency of loads. Fig. 2 shows the slab thickness needed for various wheel loads. The wheel loads shown can be carried for an unlimited number of repetitions. Larger loads can be carried with less frequency.

Jointing: Properly placed and constructed joints relieve stresses in the paving and prevent formation of irregular cracks. Concrete should be placed in longitudinal strips about 10 feet wide. Tongue and groove joints between strips transfer load from one to the other and prevent unequal displacement. Dummy grooves should be cut across the strips at 15- to 25-foot intervals. The grooves are made one-fourth the depth of the slab. Grooves may be cut in the fresh concrete or sawed soon after the concrete has set. A crack forms at the weakened plane, and the irregular faces of the crack transfer the load from one slab of concrete to the other.

At the edge of the paving the absence of an adjacent slab reduces the load-carrying capacity. For that reason, edges where vehicles come onto the pavement should be thickened by 2 inches. Where concrete abuts a permanent structure, an expansion joint is used to prevent stress buildup in the structure.

Reinforcement: Reinforcing steel, when provided in an amount within the range of practical economy, does not increase the flexural strength of the paving. *Where slabs are joined in a manner to control cracking, reinforcement has no function. On farm jobs, it is generally more economical to provide joints as described above and eliminate the reinforcement.* If steel is used, its function is to hold together the fractured faces of slabs after cracks have formed. The amount of steel for this purpose can be determined from the formula:

$$A_s = \frac{9.37\ tL}{f_s} \text{ where}$$

A_s is the steel area per foot of width or length of slab

L is the distance in feet between joints in the corresponding direction

t is the concrete thickness in inches

f_s is the allowable working stress in the steel

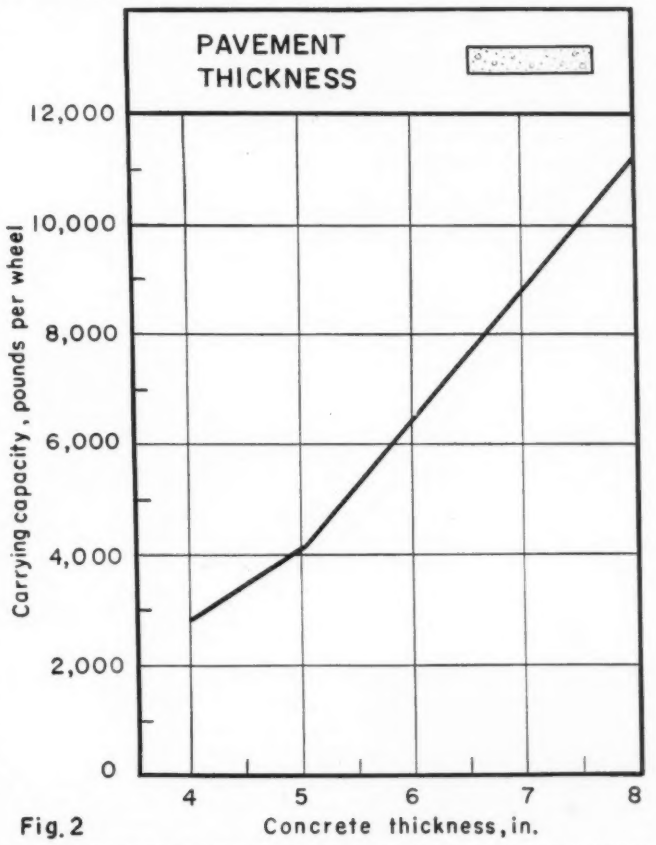


Fig. 2

Quality Concrete: Farm paving is exposed to wide variations in temperature and moisture. In addition, it is subject to severe abrasion and sometimes chemical attack. The concrete should contain approximately 6 sacks of portland cement per cubic yard and should have a maximum water cement ratio of 6 gallons of water per sack of cement. Air-entrained concrete is recommended.

For more information on farm paving, write for the free booklet, "*Pave Your Barnyard with Concrete.*" Distributed only in the United States and Canada.

PORTLAND CEMENT ASSOCIATION

Dept. 5-1, 33 West Grand Ave., Chicago 10, Illinois

A national organization to improve and extend the uses of concrete

Hay Rake with Offset Ground Wheels

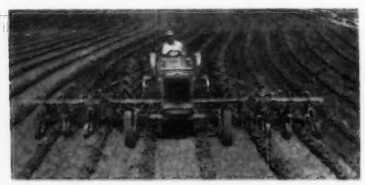
New Holland Machine Co., New Holland, Pa., has announced a new improvement in hay rakes — offset ground wheels. This feature reportedly permits the rake to

hug the ground and at the same time it helps protect the basket and rake teeth on rough ground. With this positioning of the wheels, the rake moves over high spots in the ground without snagging and through dips to get all the hay. All the teeth and basket are protected.

To rake twice as fast, two rake reels are hitched tamdem which permits double raking into a single windrow, or one rake can be reversed for making two separate windrows from two swaths in the case of heavy hay.

Six-Row, Front-Mounted Cultivator

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has announced development of a 6-row front-mounted cultivator for the D-17



tractor. A boom and turnbuckle lifts each 3-row section into position for swing-in-type quick hitching. The outside gangs are spring-balanced and fold up to reduce over-all width to that of a 4-row unit for transport.

This cultivator is adjustable for 36 to 44-in. row spacings. Long tubular steel gangs are fitted with special shank clamps and crossheads to permit good sweep or shovel patterns for cultivating a 20-ft strip.

Gangs are rigidly mounted through parallel linkage to provide lateral stability. This permits each gang to follow ground irregularities independently of other gangs for uniform cultivation of each row. The linkage design also facilitates quick penetration of the ground by shovels or sweeps without levers, springs or hydraulic rams.

Cultivating depth is regulated by a depth stop on each gang. Depth control of the rear furrowing bar is set by means of a screw-type adjustment from the tractor seat.

Hydraulic Gear Pumps

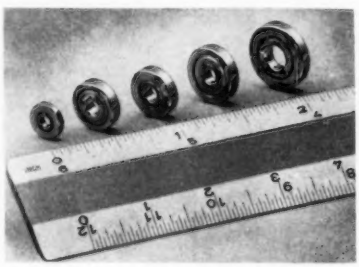
Wooster Div., Borg-Warner Corp., Wooster, Ohio, is placing on the market a new family of hydraulic gear pumps which, it is claimed, have been greatly simplified in design and engineered for longer life and higher performance.

Construction of these pumps permits pressure from the outlet port to be diverted behind the rear bearings to reduce clearance between bearing faces and gears for optimum volumetric efficiency at all speeds and pressures. Other features are special alloy tin-aluminum bearings used in heavy-duty industrial engines, double-lip shaft seal, hardened and ground steel gears and shafts, and high-tensile aluminum bodies.

The line consists of five series of pumps with four displacement variations in each series, giving a total of 20 standard pumps, all available with either side or end porting, or a combination thereof, and with standard SAE flanges and drive shafts. Capacities from the smallest to the largest series range from 0.7 to 140 gpm at 2,000 rpm and 2,000 psi.

Thin-Width Instrument Bearings

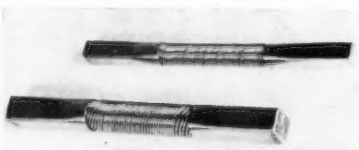
Miniature Precision Bearings, Inc., Precision Park, Keene, N. H., announces a new series of thin-width precision-instru-



ment bearings. Featuring a high outside diameter-width ratio, these new bearings were developed originally for use in synchros where precision and reliability are prime requisites. Having been found to be suited for other applications, nine thin-width bearings were included in the new standard series. The relatively large O. D. enables designers to use through-bored and through-ground housings said to result in more efficient production and improved bearing alignment. The narrow width of these bearings saves space, making it possible to use longer stators and rotors in synchros and small motors, thereby increasing power without adding to the over-all length or diameter of the unit.

Flexible Shaft Coupling

Stow Mfg. Co., 39 Shear St., Binghamton, N. Y., announces development of a unique flexible coupling made of ½ and



⅜-in. diameter stainless steel flexible shaft core that will operate at temperatures up to 1,000 F. Stainless steel sleeves are put on the ends of the shaft and then squared. The square forms the engagement for the drive and also allows for slight changes in length due to varying torques. Total length can be varied to suit the application. These new couplings are specially suited to certain controls that must operate at temperatures too high for hydraulic controls.

Power Steering Kit

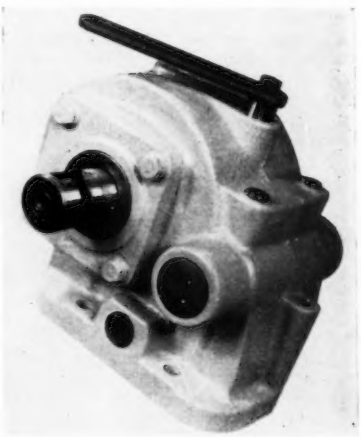
Aeroquip Corp., Jackson, Mich., announces development of a power steering kit for replacing hydraulic pressure and re-

turn lines on power steering units. The kit is supplied with a handy coil of hose and a variety of reusable fittings, in fact, everything needed to make dependable replacements on power steering units. With the basic inventory the kit contains, a mechanic can quickly assemble power steering pressure and return lines to any length, the only tools required for assembly being a wrench and vise.

Simple instructions are illustrated inside the cover of the kit and parts are identified to facilitate reordering of individual fittings, adapters, and hose.

Extra Heavy-Duty Power Take-off

Dana Corp., Standard Equipment Div., 4100 Bennett Rd., Toledo, Ohio, offers a new extra-heavy-duty power take-off (Spi-



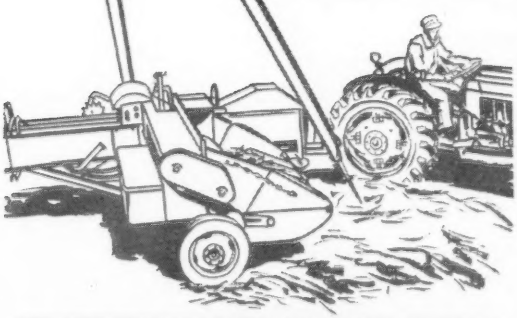
cer PNG6) that is capable of transmitting 240 ft-lb of torque intermittently. This new unit was designed especially for use on the Spicer 8125 synchromaster 12-speed transmission.

(Continued on page 320)

Buy a Rollway

engineered to your needs . . .

Margins of safety are important, of course. But quality and precision unused and unusable over the life-expectancy of the implement are wasteful. That's why each Rollway implement bearing is engineered for the specific range of loads, speeds, maintenance and storage normally encountered in the machinery for which it is designed. For example . . . .



Split Sleeve Bearing Makes Simplicity Pay

Simple, practical in design, the bearing picture above gives you a *choice* of "life expectancies", for it is available: 1. Unhardened and unground; 2. Hardened and unground; 3. Hardened and ground. To assemble, simply press the sleeve in housing at unit-assembly bench, then slide the bearings on shaft at the group assembly station. Fast . . . easy . . . less costly!

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BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Free Engineering and Metallurgical Counsel

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ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

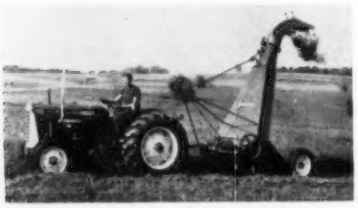
. . . New Products

(Continued from page 318)

While designed basically for transmissions with a high pitch-line velocity (those giving extremely high power take-off speeds), this new series is nevertheless available in models suitable in pitch for use with other types of transmissions.

Flail Chopper

The Oliver Corp., 400 W. Madison St., Chicago 6, Ill., announces production of a new flail chopper (model 48) that has 28



free-swinging knives that, revolving at a speed of 1750 rpm, develop the propulsion velocity needed to throw cut forage out of the delivery spout into a wagon. Neither auxiliary blower nor auger is needed. For mulching, the hood and spout can be removed and the chopped material expelled evenly over the ground. The knives are staggered and the cylinder is balanced to provide clean, fast cutting. Cylinder height is adjustable to cutting ranges of 2 to 14 in. above ground level.

Delivery height of the spout is 12½ ft, and spout delivery can be shifted in an 180-deg arc by means of a crank control. Features include a three-belt V drive and a 50-hp gearbox. The machine has anti-friction, self-aligning bearings for smooth, quiet operation. Tread adjustment ranges from 22 to 66 in.

Utility Line of Tractors

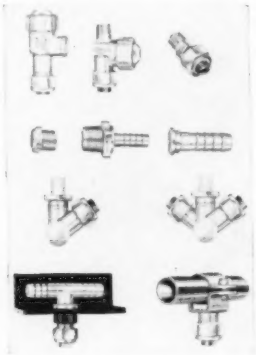
J. I. Case Co., Racine, Wis., announces three new series of wheel and crawler tractors and new, high-capacity companion

power equipment for 1960, known as the utility line. This line offers equipment for heavier duty construction, faster and smoother operation, and higher output performance than preceding models. It includes the Model 530 wheel tractor powered by a 47-hp engine, the Model 430 wheel tractor powered by a 38.5-hp engine, and the Model 310D crawler tractor powered by a 42-hp engine. Companion equipment especially designed and built for this line of tractors includes backhoes, front-end loaders, bulldozers, angling dozers.

Both wheel and crawler tractors are designed for extra usefulness with a wide variety of quick-change front and rear attachments. The rear attachments include all-purpose blade, scarifier-scraper, scoops, hydraulic scarifier, winch, posthole digger, post driver, and other specialized tools. Side-mounted, cutter-bar mowers can be kept mounted at the same time as the loader on all wheel tractors.

Nylon Spray Nozzles

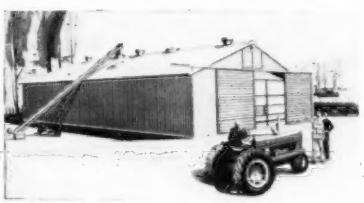
Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., offers a large selection in sizes and types of farm spray nozzles and



parts of nylon for users who prefer them. All nozzle parts are made of nylon, with the interchangeable orifice tips in choice of stainless steel, aluminum, or brass. The strainer screens are made of stainless steel. To complete its spray nozzle line, the company recently introduced a new direction valve for selective spray control of boom sprayers, as well as a new diaphragm pressure-relief valve. Both of these accessories are designed so that all parts that touch chemicals are made either of nylon or stainless steel. The diaphragm of the relief valves is made of a special corrosion-resistant material that remains resilient in the presence of all farm chemicals.

Compact Grain Storage

Stran-Steel Corp., Division of National Steel Corp., Detroit 29, Mich., announces a new, compact grain-storage building de-



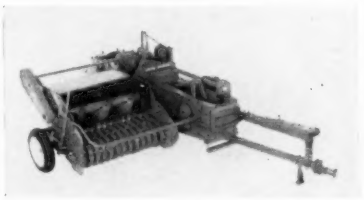
signed for farm storage of 3,000 to 10,000-bu capacity, plus utility storage — in fact, a full-time farm building.

It has a steep roof slope closely matching the natural slope of piled grain, which permits loading the building to full capacity without interior handling. The building has a 10-ft eave and can be had in any length of 32 ft and longer in multiples of 16 ft, to fit any crop requirement. It has the Stran-Steel grain storage or drying system; it is of all-steel construction, double or single walls, 10-ft door bulkhead, roof vents, grain hatches, and an easy-access end wall louver. It is available in a choice of nine metallic colors, including white.

As a feed center, there is column-free interior space sufficient to set up grain-processing and handling systems. A 20-in.-diameter loading hatch is ridge mounted and accommodates standard elevator spouts. The large-capacity, hinged-type ventilating louver is designed for variable weather and air requirements. Also, it is fitted with an inner screen to keep out birds and insects.

Wire-Tie Baler

Deere & Co., 3300 River Dr., Moline, Ill., announces the addition to its baler line of a new wire-tie baler — the 214-WS,



which makes heavy bales weighing around 80 lb. Bale length can be varied from 8 to 50 in. The machine is specially adapted for large operators.

This baler features a new single-twist knotter which provides greater tying accuracy, simpler adjustments, and easier servicing. Also, it is equipped for "push button" ease of lubrication.

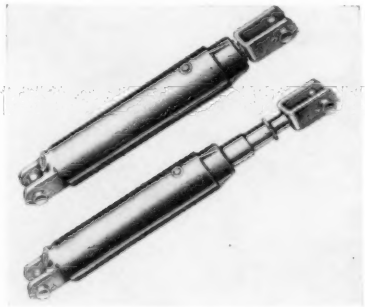
Like all of the company's balers, the 214-SW baler has bale groovers built into the bale case so that the baling wire can be drawn snug to the bale, to reduce snagging or slipping in handling. Other features include an extra wide pickup, hip-high strippers, large floating auger and fork-type feeder, and knife-equipped, continuous-running plungerhead.

In addition, this baler features a combination overrunning and slip clutch on the power take-off, combination slip clutch and shear assemblies in the flywheel, slip clutches in the auger and pickup drives, and protection against needle damage.

The machine is available for power take-off operation or with a 26½-hp Wisconsin engine.

Stroke Control Cylinder

Prince Mfg. Corp., 4th and Water Sts., Sioux City, Iowa, has made a new addition to its line of standard stock hydraulic cylin-



ders by including both a 3-in. and a 3½-in. bore by 8-in. stroke ASAE standard cylinder. These units feature positive mechanical stroke control over 4 in. of stroke, with adjustments that can be made easily and quickly by hand. This line is available through farm equipment distributors throughout the country.

(Continued on page 323)

Constant Ratio

Variable† Ratio

†Originated and developed by Ross

● Wherever the job calls for alert, responsive, fatigueless steering . . . Ross *variable-ratio* steering is at its best!

Ross *variable-ratio*—faster steering and quicker recovery for turns, and slower steering and greater stability for straight-ahead handling—has been adopted by 31 of today's leading vehicle manufacturers. Ross invites *your* inquiry.

Ross STEERING

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Gemmer Division • Detroit

HIS HOME-MADE BULLDOZER LEVELS THE GROUND FAST!

Dan Curtiss (left) whose family farm near The Dalles, Oregon, produces up to 350 tons of cherries annually, wanted a bulldozer. So, he built it himself! He utilized the rear end of an old car, operating off the tractor power take-off, to raise and lower the blade. Welded iron "baskets" on each side can be loaded with stones to increase weight on the blade when needed. Works just fine, too!

Dan and his father before him have been using Texaco products for over 20 years. Texaco Consignee R. M. Brown (right) supplies the farm with Texaco products, including Marfak. Marfak is preferred for lubricating bearings of farm machinery because it won't jar off, dry out or cake up, melt down or wash off. Mr. Curtiss has found that *it pays to farm with Texaco products.*

He likes Texaco's dependable delivery

H. B. Winslow (at right) farmer near Williamston, N. C., takes time out for a friendly chat with Melton Ayers, driver for the Robersonville Oil Company, Texaco Distributors.

"I like the dependable deliveries I get from the Robersonville people," he says. "When a farmer needs gasoline or oil, he wants it delivered on time."

Mr. Winslow farms 172 acres, raising tobacco, sweet potatoes, corn and peanuts. He has rigged up an attachment to his irrigating system so that the pump operates from the power take-off of his tractor.

This progressive farmer uses Texaco Fire Chief gasoline exclusively for his power machinery. He knows that Fire Chief's lively fire-power gives more draw-bar pull. Advanced Custom-Made Havoline Motor Oil is used for lubrication of the tractor, truck and other equipment. Mr. Winslow is another of the many thousands of farmers who know that *it pays to farm with Texaco products.*

BUY THE BEST...BUY TEXACO

TUNE IN: TEXACO HUNTLEY-BRINKLEY REPORT, MONDAY THROUGH FRIDAY, NBC-TV

. . . New Products

(Continued from page 320)

New Design of High-Strength Bolt

Russell, Burdsall & Ward Bolt and Nut Co., 100 Midland Ave., Port Chester, N. Y., announces a new design of high-strength bolt with larger head and shorter thread length, which it says will substantially increase the present advantage of such bolts over other types of structural fasteners. Savings up to 40 percent in bearing-type connections are claimed over present high-strength bolts due to the new head and thread design. The new design is said to include the following advantages:

(a) Larger bearing area under the head requires use of only one washer per bolt. The washer can be used under either bolt head of nut, whichever is rotated in tightening.

(b) Shorter thread length prevents the shear plane of the connection from passing through the threaded portion of the bolt.

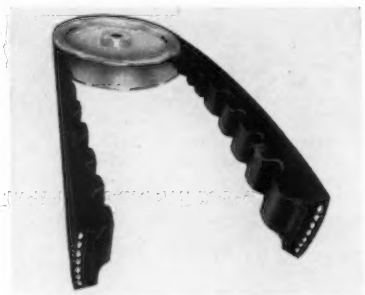
(c) The large-head bolt has the same across-flats dimensions as the presently used heavy nut, eliminating the requirement for the two different wrench openings presently needed.

(d) Tightening is possible from either nut or bolt head, an advantage where clearance is a problem. The hardened washer is used under the rotated member.

(e) Exact alignment of holes in structural members is unnecessary. Misalignment up to 1/16 in. will still permit easy hand insertion of the bolt.

Notched V-Belt

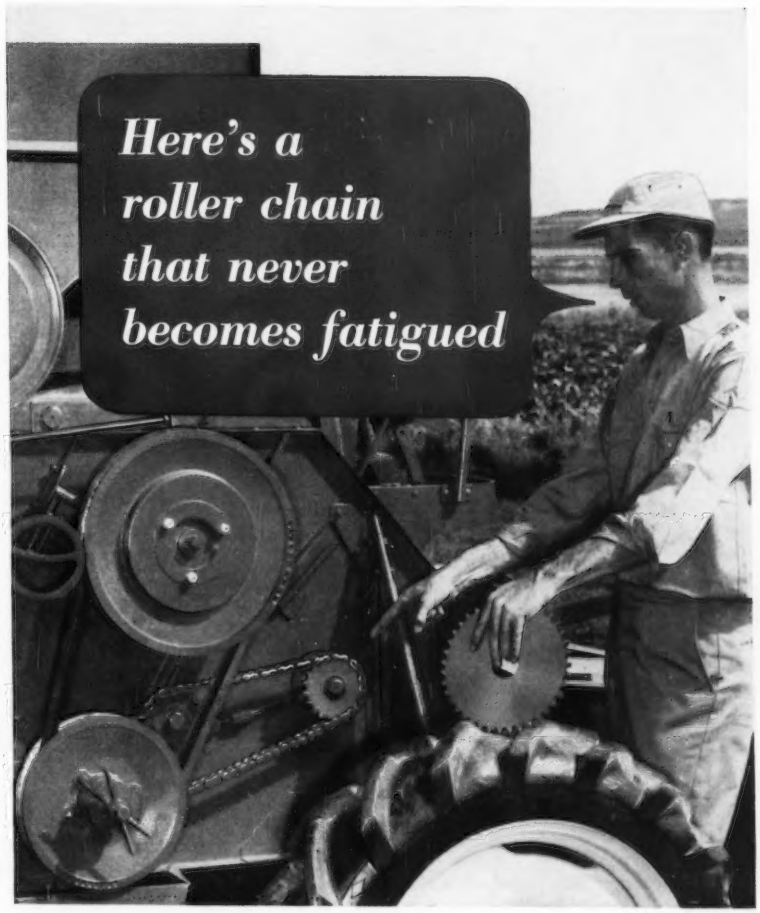
Raybestos-Manhattan, Inc., Manhattan Rubber Div., Passaic, N. J., announces development of a new fully molded, fully



jacketed, notched V-belt, which is said to be the only construction of its kind in industry. Primary advantages claimed for this belt are its quiet, vibrationless running characteristics, as well as its ruggedness and flexibility which permit it to run smoothly over smaller pulleys. In addition, the molded and jacketed construction eliminates flex-cracking and increases fatigue resistance. The firm, fabric-covered body also resists cross-sectional distortion, maintains lateral stability, and resists changes in effective length. Also, it is quiet and vibrationless, and cool running.

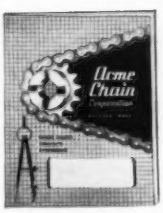
In this V-belt, the high-tensile-strength members are micropositioned and formed into an arch through a patented molding process, which is said to result in increased sidewall pressure. At present, this new notched V-belt is available only to original equipment manufacturers.

(Continued on page 334)



Farm machinery requires a roller chain that is rugged, dependable and economical — a chain that never "gives up" in the middle of a job. ACME chains are engineered for tough work. Whether ploughing, dragging, mowing, binding or threshing, they are made to give positive power transmission — without friction loss or slippage — which results in savings. All ACME chains undergo rigid tests before leaving the plant to assure you of the utmost in quality and trouble free service.

Call your nearest Authorized Distributor for further details and assistance. They have the full cooperation of our engineering and production department.



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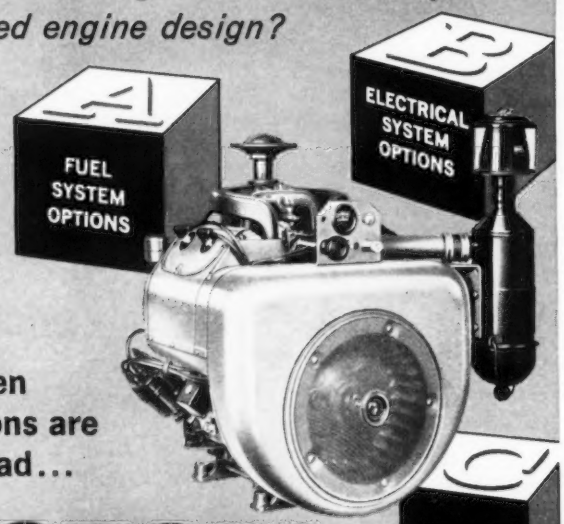
COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

looking for "building-block" flexibility in air-cooled engine design?



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CUSTOM ENGINEERED

engine power by WISCONSIN

Actually, it's as simple as ABC — and just as economical — to modify a regular production model Wisconsin engine to your own special requirements with our *custom engineering* service.

Wisconsin power specialists work with you in making the proper selections from among scores of optional arrangements available to cover: fuel and electrical systems, power drives, power take-off systems, speed controls, hydraulic equipment, fuel-tanks, rotating screen, pre-cleaner, and various other specification options.

Where more extensive modification is necessary, Wisconsin engineers also counsel on most economical methods of re-designing basic components and accessories to your needs. Their aid brings you a background of more than 50 years of heavy-duty power-unit specialization. Their recommendations can be relied upon for producing an engine to fit your requirement.

Send us a summary of your power problems to initiate immediate assistance from Wisconsin engineers. There is no obligation and you save development time and expense.

Send for your copy of Wisconsin Bulletin No. S-249 giving technical data on the complete Wisconsin Engine line. Write Dept. O-40.

ACCESSORY OPTIONS

FUEL SYSTEM — gasoline, natural gas, or LPG (for domestic use) and alcohol, kerosene, or No. 1 fuel oil (for export).

ELECTRICAL EQUIPMENT — electric starter-generator system or electric starter only for all models. Solenoid switches and automatic choke, for remote or automatic starting, also available.

HYDRAULIC POWER — all Wisconsin V4's can be equipped with integrally-mounted hydraulic pump.

POWER DRIVE—centrifugal clutch; over-center clutch; clutch reduction or reduction assembly in a variety of ratios; adaptor to take a spring-loaded clutch; or transmission-torque converter designs.

DIRECT DRIVE — special crankshaft extensions are available threaded, tapered, splined, special diameters and lengths, various keys, etc., for close-coupled pumps, generators, and other equipment.

SAFETY DEVICES — low-oil-pressure cut-off switch for 2- and 4-cyl. models, and high-temperature safety switch for all models.

OTHER ACCESSORIES — automotive and spark-arresting mufflers, pre-cleaners, drive pulleys for flywheel, rewind starters for ACN and BKN engines, and others.

O-148

WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

MANUFACTURERS' LITERATURE

Literature listed below may be obtained by writing the manufacturer.

Picture Window Milking Parlor

Babson Bros. Co., 2843 W. 19th St., Chicago 23, Ill.— A 16-page booklet describes the Surge picture window milking parlor, including its 6-point system — the loafing area; calf, maternity, hospital facilities; the feeding area; the lot area; the holding area; and the milking parlor.

Engineered Milling Brochure

Paul Berg, Feed Industry Consultant, 406 Transfer Building, Fort Wayne 2, Ind.— An 18-page illustrated engineering brochure contains ideas for modernizing feed mills and includes application information and methods for planning modernization. It is indexed and represents a wide range of equipment found in a feed mill.

Bearing Booklet

Aluminum Company of America, 1501 Alcoa Bldg., Room 732, Pittsburgh 19, Pa. — A 90-page study titled "Alcoa Bearings" describes an extensive collection of case histories, engineering, and test data pertaining to aluminum sleeve bearings and bushings. The art and science of designing aluminum bushings (single piece hollow cylinders) from pieces no larger than a fingertip to gigantic 4-ft diameter units weighing ¾ ton and built to support loads of more than 5-million pounds are discussed in the booklet. Charts, graphs, drawings, and photographs are used in the technical discussion.

General Engineering Catalog

Dodge Manufacturing Corp., Mishawaka, Ind.— A 468-page general engineering catalog (No. D60) describes all products in company's mechanical power transmission equipment line, and includes an 8-page index. Various sections are devoted to both new and established product categories, with engineering drawings, dimensions, weights, prices, technical data in tabular form, and many pages of helpful selection and application information. Requests should be made on company letterhead.

Universal Joints and Drives

Neapco Products, Inc., Pottstown, Pa.— A 16-page engineering bulletin describes complete line of universal joints and drives. Three series are covered, each in its own section, from light-duty slow-speed, hand-operated joints through medium and heavy-duty industrial and farm tractor power take-off drives. Each section contains complete specifications, such as dimensions, performance ratings, drive shaft types, plus a list of standard yoke part numbers with complete data on bore sizes, keyways, and setscrew holes.

Heat and Corrosion-Resistant Castings

The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.— An illustrated 64-page booklet entitled "Heat Resistant Castings . . . Corrosion Resistant Castings . . . Their Engineering Properties and Applications" is designed as an aid to those interested in the stainless steel and high-alloy casting selection, design and production. It is divided into three sections: Heat-resistant alloys, corrosion-resistant alloys and fabrication data. This material is supplemented by 13 tables and technical information on heat and corrosion-resistant castings, as well as photographs.

Speed Reduction Units

Dodge Manufacturing Corp., Mishawaka, Ind.— Bulletin A692, a 64-page booklet,

describes modern methods of speed reduction with compact, shaft-mounted units in a wide range of sizes and horsepowers. In addition to an expanded line of torque-arm speed reducers for mounting on shafts of driven machines, it also presents reducers for flange mounting, vertical shafts, right-angle drives and screw-conveyor drives. Construction details, dimensions, prices, and installation information are given in sections illustrated with photographs and engineering drawings. Tables are included to simplify selection of reducers for various applications, power requirements and output speeds. Also included are tables listing V-belt drives recommended for use with torque-arm and other reducers and screw conveyor drives to achieve any output speed, plus a section on screw conveyor drives.

Roller Chains, Sprockets and Bearings and Pillow Blocks Literature

Link-Belt Company, Department PR, Prudential Plaza, Chicago 1, Ill. — A 44-page book, No. 2757, is "keydexed" for easy reference and lists over 2,000 types and sizes of stock roller chains and sprockets, including standard and double pitch power transmission chains, a large selection of conveyor chains and attachments, and a complete line of sprockets. An 18-page section lists stock sizes of standard roller chains—single, double, triple and quadruple strand—together with heavy series roller chains, corrosion-resistant stainless steel and bronze roller chains, double pitch roller chains, various types of flat-top conveyor chains, and leaf chain. Sprockets described in a 20-page section include the finished bore, taper lock, mandrel bore, type D (removable segments) and shear pin types. Two pages are devoted to RC roller chain flexible couplings.

Book 2760, 52 pages, describes line of highest capacity spherical roller bearings, which combine three features: Maximum diameter and quantity of convex rollers for each bearing size; precision machined centrifugally-cast bronze retainers and high, heavy inner race shoulders. Included are all design features, selection data and formulae, shaft bearing seat diameters, lubrication information, shaft details and bearing load ratings, diagrams, photographs and charts.

Land Equipment Literature

Caterpillar Tractor Co., Peoria, Ill. — Offers the following five pieces of literature:

A 24-page booklet on major products briefly describes and illustrates the product line and gives brief specifications.

Form 33611, entitled "The New Work Styled D6," is a 12-page, two-color booklet that describes the D6 Series B tractor, and lists its specifications, attachments and tool for logging, agriculture, and other applications.

A 12-page, 2-color booklet, Form 33550, entitled "Caterpillar Presents the All New D4 Series C Tractor" describes and illustrates the D4 tractor and tells of its new diesel engine and a lifetime lubricated undercarriage. Also described is the high ground clearance of the tractor, its traction and ability to perform on soft footings.

An 8-page book entitled "To Meet the Continuing Challenge" deals with the scope of research and development invested by the company in its program of continual product improvement. It discusses such innovations as the swing-away dash, the floating ring seal, and the design of the power shift transmission.

Form DE918, a 6-page bulletin entitled "Some Facts of Engine Life" outlines steps that can be taken to minimize engine downtime and includes reconditioning tips, and maintenance suggestions.

Ball Bearing Hose Swivel

OPW-Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio — Bulletin NP-20-E covers the features, specifications and complete engineering information, plus illustrations, of the ball bearing hose swivel.

Service Parts Catalog

The Electric Autolite Co., Service Parts Div., Toledo 1, Ohio — A 39-page service parts catalog (No. S-32FS) contains data for 1959-60 farm equipment, and is a supplement to the previous editions issued in 1958. It fits into the regular counter catalog binder and includes complete parts specifications of major manufacturers of tractors and other self-propelled farm machinery.

Hay Baler Catalog

New Holland Machine Co., Div. of Sperry Rand Corp., New Holland, Pa. — A 12-page, 4-color catalog, Form 4815, covers the series 60 hayliners and is illustrated with photos and cutaway page drawings to show the inner workings of the 69 hayliner. In addition to these pages, it also includes information on the models 67 and 68 hayliners.

Gasoline Engines

West Bend Aluminum Co., Industrial Engine Div., Hartford, Wis. — A 4-page, 2-color bulletin, Eng. 215, lists specifications, in addition to describing and illustrating the series 390, 580, and 700 gasoline engines. Optional equipment for basic engine is also shown and described.

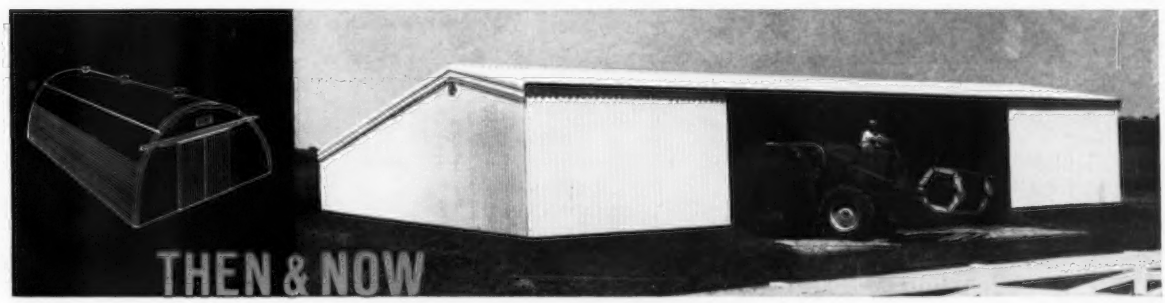
Motor Literature

General Electric Co., Schenectady 5, N. Y. — Offers the following three pieces of literature:

Bulletin GEA-6424A, a 12-page, 4-color publication, discusses and illustrates the

(Continued on page 335)

STRAN-STEEL PRE-ENGINEERED FARM BUILDINGS



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RESEARCH NOTES

Brief news notes and reports on research activities of special agricultural-engineering interest are invited for publication under this heading. These may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Michigan.

British Expert Cites Slatted Floors

Slatted floors for livestock structures were cited by a farm buildings expert from London, England, during a recent visit with the AERD staff at USDA's Agricultural Research Center, Beltsville, Md.

Travers Legge — chairman of the British Farm Buildings Association, farm buildings advisor of the *Farmers Weekly*, and ASAE member — was enroute to Australia and New Zealand after receiving a travel scholarship.

While reporting on European agricultural developments, Mr. Legge said slatted floors are being used successfully without straw litter in Iceland, Norway, and other litter-short countries of northern Europe. Results vary in British trials that are continuing. Agricultural engineers of AERD believe slatted floors could be useful in the United States.

Slatted floors not only greatly reduce litter costs, but also lessen per-head costs because building capacity is increased. When beef cattle and calves were on slatted floors two winters in one European test, litter savings were enough to pay for installing the floors. Animals were quieter than usual and not affected by parasites ordinarily found in straw litter.

The wood or concrete slats are installed in widths and spacings that allow stock to move freely without injury, Mr. Legge said. Manure drops through the slots to a cellar that is sealed at the sides to prevent drafts and loss of heat.

Although the slats are not usually cleaned, manure can be removed from the cellar mechanically. A little sawdust is applied to help keep the slats dry. Odors are not strong enough to be objectionable.

Mr. Legge later visited the agricultural engineering department of the University of California, Davis. At a staff luncheon, he gave an illustrated talk on Britain. ARS agricultural engineer Thayer Cleaver and members of the California staff conducted Mr. and Mrs. Legge on a tour of livestock installations between Davis and Los Angeles.

Vilander Starts Farming

Agricultural engineer Dean R. Vilander, who joined the Farm Electrification Research Branch, AERD, ARS, USDA, in May 1957, has resigned to engage in farming near Vancouver, Wash. Mr. Vilander was stationed at the Western Washington Agricultural Experiment Station, Puyallup, where he developed an electrically driven horizontal silo unloader.

Report on High Quality Hay

A new report on high quality hay points out that more extensive use of research findings would enable many dairy farmers and livestock growers to operate more efficiently.

In a discussion of hay quality and production, the report emphasizes three general rules: *(a)* Aim for high nutrient content in growing plants; *(b)* Cut hay early when nutrients are near peak; and *(c)* Dry hay rapidly to conserve feeding value.

Information for the report was provided by several divisions of USDA's Agricultural Research Service and the Grain Division of the Department's Agricultural Marketing Service.

Copies of the report are available from the ARS Information Division, USDA, Washington 25, D. C. Request ARS Special Report 22-52, "High Quality Hay."

Modified Furrow Opener Best

Best emergence and stands of cotton resulted after use of a modified curved-runner seed furrow opener in tests of planting equipment by USDA-State researchers at Pecos, Tex. Soil was not pressed over cottonseed 1½ to 2 in. deep.

The device performed well on lister, loose-ground attachment, and plateau types of cotton planters.

Experiments were conducted by agricultural engineer E. R. Holekamp of AERD, ARS, USDA, and agronomist E. L. Thaxton of the Texas Agricultural Experiment Station.

Their report is available from the Texas station at College Station. Ask for Progress Report 2122, "Cotton Planting Equipment Tests at Pecos, 1959."

USDA Advisory Committee Cites Research Needs

Several major research efforts by agricultural engineers were recommended by USDA's Farm Equipment and Structures Research Advisory Committee at its annual meeting Feb. 9 to 12 at Stoneville, Miss.

The committee urged studies aimed at increasing knowledge of: *(a)* equipment and

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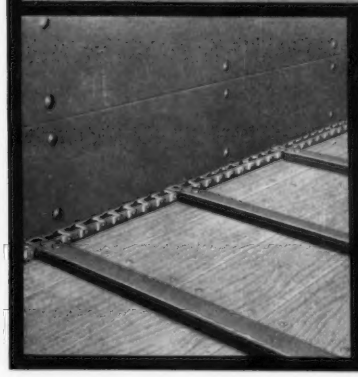

The bed conveyor on the New Idea No. 600 Forage Box is driven over cast sprockets by Locke Steel Pintle Chain. Steel conveyor slats are riveted to Locke attachment links. Maximum conveyor speed of seven feet per minute assures fast unloading from side or rear into blowers, feed bunks or pit silos. New Idea engineers specified Locke Steel Pintle Chain for its high tensile strength, good appearance, low cost and the years of trouble-free operation which are designed and built into this chain. The rugged dependability, pitch uniformity and wear resistance of Locke Steel Pintle Chain makes it ideal for use in power transmission applications. Attachment links are available for a variety of conveying applications. Write now for complete information — available in Catalog 60.

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methods for applying pesticides; *(b)* planting and fertilizing equipment and practices; *(c)* drainage facilities and equipment; *(d)* equipment for harvesting and ginning cotton; *(e)* influence of environment on farm animals and poultry; *(f)* farmstead water supply and wastes disposal; *(g)* farm layout, building design and arrangement, electric and mechanized equipment, and controls for automatic systems; and *(h)* farm safety.

Recommendations for the research are submitted formally to USDA by the committee, established under the Research and Marketing Act of 1946. Research undertaken will be performed by the Agricultural Engineering Research Division and other divisions of USDA's ARS, in cooperation with State Agricultural Experiment Stations and industry.

Price Hobgood, head of the agricultural engineering department at the Texas Agricultural and Mechanical College, College Station, was re-elected chairman of the advisory committee. Charles F. Morrison, Zillah, Wash., fruit grower, was renamed vice-chairman.

Other members of the committee are: John W. Carpenter, cotton producer, Tallulah, La.; Dale Erlewine, dryland grain producer, Grant, Nebr.; Richard K. Frevert, director of the Arizona Agricultural Experiment Station, Tucson; Berryman R. Hurt, dairy and hog producer, Dunlap, Ill.; W. G. Kaiser, agricultural engineer, Glen Ellyn, Ill.

Also, J. H. Oliver, manager of sales promotion for the Aerovent Fan and Equipment Co., Lansing, Mich.; Mrs. Evalyn Bergstrand Owens, farm homemaker, Dousman, Wis.; Russell R. Poynor, general supervisor of farm practice research, International Harvester Co., Chicago; and A. L. Vandergriff, president of the Continental Gin Co., Birmingham, Ala.

Copies of the committee's report are available from its executive secretary, Carleton P. Barnes, Office of the Administrator, Agricultural Research Service, USDA, Washington 25, D. C.

Recent Publications

A research report on a transistorized power supply and automatic-control unit for battery operation of survey-type electric insect traps and a reprint of an article on new ideas for cleaning hard-to-handle seeds are available.

Authors of the report on the power supply unit are J. P. Hollingsworth and C. P. Briggs, agricultural engineers of the Farm Electrification Research Branch of AERD in USDA's ARS. Their research was conducted in cooperation with the Texas Agricultural Experiment Station at College Station. Currently, they are studying the response of cotton insects to variations in frequency and intensity of electromagnetic radiation.

Agricultural engineer J. E. Harmond, well known for his work in developing improved seed processing equipment, prepared the article on cleaning seeds. He is head of the Small Seed Harvesting and Processing Section, AERD, ARS, USDA, Corvallis, Ore. Work done there is in cooperation with the Oregon Agricultural Experiment Station.

The report on the power supply unit, ARS 42-38, will be sent by the Information Division, ARS, USDA, Washington 25, D.C. Reprints of "Some New Ideas for Cleaning Those Hard-to-Handle Seeds" will be mailed by the Harvesting and Farm Processing Research Branch, AERD, ARS, Room 326, North Building, USDA Plant Industry Station, Beltsville, Md.

NEW FILM RELEASES

Silver Threads Amass the Gold. 16mm. 25 min. Color and sound. The film features the larger production, semi-production and maintenance type threading machines, including the correct operation of them, for best performance and satisfactory results. It is of interest to and informative for anyone having anything to do with the threading of pipe, bolts, rods, and conduit. It is available, at no cost, to any responsible organization such as trade associations, vocational classes, foreman groups, contractors, engineers, and others in similar fields of work, from The Oster Manufacturing Co., 1340 E. 289th St., Wickliffe, Ohio.

Man and Masonry. The masonry industry esthetics program for architects employs a motion picture film, a book, and a high fidelity recording. The film examines masonry through scale, nature, form, light, screens, pattern, texture, sculpture, and emotion; and to give it additional depth, a musical score was written for the soundtrack which discusses in aural terms the visual esthetics of architecture. At the same time that the film was being produced, a "Man and Masonry" picture book, employing the same photographs was edited. In order to give the book the same aural dimension of the film, a high fidelity recording was made from the soundtrack. The recording sleeve is a part of the back cover of the book. The book is designed to be looked at as the music is played on a phonograph, thus relating the two arts. For information write to Structural Clay Products Institute, 1520 18th St., N.W., Washington 6, D.C.

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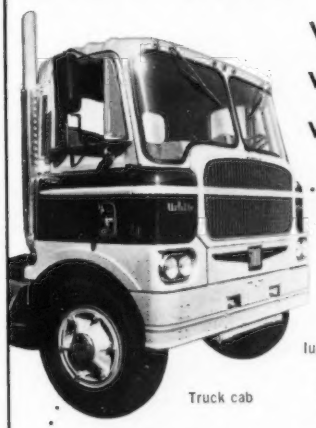

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The following bulletins have been released recently. Copies may be obtained by writing to author or institution listed with each.

The following articles are reprints from the *Quarterly Bulletin*, Vol. 42, No. 3, February 1960, of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing, and are available from this source:

Article 42-50 — Pages 548 to 557, *"The Effect of Soil Compaction on Moisture Absorption by Sugar Beet Seeds,"* by B. A. Stout, F. W. Snyder, and W. F. Buchele.

Article 42-53 — Pages 584 to 595, *"Nail-Glued Wood-Plywood Beams for Residential Construction,"* by B. M. Radcliffe, A. W. Sliker, and D. F. Luebs.

Article 42-45 — Pages 511 to 522, *"The Design of Prefabricated Wall Panels for Poultry Houses,"* by Merle L. Esmay.

Article 42-47 — Pages 527 to 533, *"Development of a Fruit Tree Hedger,"* by C. M. Hansen and S. L. Hedden.

Mechanizing the Harvest of Red Tart Cherries, by J. H. Levin, H. P. Gaston, S. L. Hedden, and R. T. Whittenberger. Article 42-60, reprinted from the *Quarterly Bulletin*, Vol. 42, No. 4, May 1960, of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing, and is available from this source.

The following publications are available from the International Institute for Land Reclamation and Improvement, Wageningen, P.O.B. 45, Holland:

Bulletin 2 — *Some Aspects of Sprinkler Irrigation in Tropical Regions*, reprinted from the *Netherlands Journal of Agricultural Science*, Vol. 7, No. 2, May 1959. Written in English.

Publication 2 — *Subirrigation in the Zuiderzee Polders*, by Ir. C. Kalisvaart. Written in English.

Publication 5 — *Water Deficiencies in European Agriculture*, by J. C. J. Mohrmann and J. Kessler. Written in English.

Lumber Rigid Frames for Farm Buildings, by J. O. Curtis and E. L. Hansen. Circular 812, December 1959. Extension Service in Agriculture and Home Economics, University of Illinois, College of Agriculture, Urbana, Ill.

The following bulletins are available from the Agricultural Engineering Dept., University of Massachusetts, Amherst:

Poultry House Ventilation in New England, prepared by the 1959 New England Council Farm Electric Service Subcommittee on Poultry House Ventilation.

Farm Building Insulation, by J. T. Clayton and C. A. Johnson. Publication 348.

Dairy Barn Ventilation, by J. T. Clayton and C. A. Johnson. Publication No. 339.

Farmstead Engineering for Dairy Farms, by J. T. Clayton, R. W. Kleis, and S. N. Gaunt. Publication 351.

A Bibliography of Farm Buildings Research — 1945-1958: Part I Buildings for Pigs. Agricultural Research Council, Cunard Bldg., 15, Regent St., London, S.W.I., England. Price 2s. 6d.

Agricultural Engineering . . . A Career with an Unlimited Future. Agricultural Engineering Dept., University of Georgia, Athens.

Report on Sprinkler Irrigation in Israel, 2nd Edition. January 1960. The Jewish Agency for Israel, Land Settlement Dept., Irrigation Div., P.O.B. 7053, Tel-Aviv, Israel.

Field Husbandry, Soils and Agricultural Engineering Division Progress Report — 1954-1958. Experimental Farms Service, Canada Department of Agriculture, Ottawa, Ontario, Canada.

Nailed Trussed Rafters with Hardboard Gusset Plates, by E. George Stern. Bulletin No. 40, August 1959. May be obtained from Virginia Polytechnic Institute, Wood Research Laboratory, Blacksburg, Va.

Part I — Wood Construction and Assembly in Europe and Asia and Part II — Wood I-Beams and Girders, by E. George Stern. Bulletin of the Virginia Polytechnic Institute, Engineering Experiment Station Series No. 133, Vol. LII, No. 10, August 1959. Available at Virginia Polytechnic Institute, Blacksburg, Va.

The following bulletins may be obtained from the University of Kentucky, Cooperative Extension Service, Lexington, Ky.

Leaflet 222—*Water Supply for Farm and Home,* by Kermit Mills.

Circular 519-A — *Use of Anhydrous Ammonia as a Nitrogen Fertilizer,* by P. E. Karaker and J. B. Kelley.

Circular 546-A—*Tobacco Plant-Bed Management,* by Russell A. Hunt, Ira E. Massie, and George A. Everette.

Circular 566 — *Treating Pond Water for Farm and Home Use,* by Jesse B. Brooks and Kermit C. Mills.

Bulletin 668 — *Some Effects of Irrigation and Fertilization of Permanent Pastures in Kentucky,* by W. C. Templeton, Jr., C. F. Buck, D. M. Seath, P. G. Woolfolk, and E. N. Fergus. June 1959.

Progress Report 92 — *Construction and Heating of Plastic Greenhouses,* by E. M. Emmert.

A Training Plan for Personnel Engaged in the Application of Electricity to House Heating. REA Bulletin 142-2, February 1960. Rural Electrification Administration, USDA, Washington 25, D.C.

Too Much or Too Little. Water Resources Association of the Delaware River Basin, 948 Suburban Station Bldg., Philadelphia 3, Pa.

Space Requirements for Home Sewing, by Frankye E. Bland, Jessie J. Mize, and Joseph W. Simons. Bulletin N. S. 69, July 1959. Georgia Agricultural Experiment Station, University of Georgia College of Agriculture, Athens.

Investigations into Braking of Tractors and Trailers, by Sigfrid Bjerninger. No. 138, 1959. Written in English. The Royal Institute of Technology, Stockholm, Sweden.

The following test reports are available from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England:

No. 238 — *Report on Test of Scotmec 10-CWT Food Mixer.* January 1960.

No. 240 — *Report on Test of McCormick International Farmall BO459 Diesel Tractor.* December 1959.

No. 241 — *Report on Test of "Ganwick" Sectional Glass Frames.* January 1960.

No. 239 — *Report on Test of Rivierre-Casalis, Model NRA, 2-075 Pick-Up Baler.* November 1959.

Publications List on Tillage and Traction. Bulletin ARS 42-40, March 1960. Agricultural Engineering Research Div., ARS, USDA, Plant Industry Station, Beltsville, Maryland.

The following bulletins may be obtained from the Ontario Agricultural College, Guelph, Ontario, Canada.

Circular 333 — *Drainage System Repair Recommendations,* by R. W. Irwin. November 1958.

Project No. A. Eng. 26 — *Measurement of Air Flow in Mow Dryers by Use of a Hot Wire Anemometer,* by C. P. Hedlin. June 1959.

Project No. A. Eng. 29 — *Report On an Experimental Continuous Flow Hay Dryer,* by C. P. Hedlin and J. W. Garland. June 1959.

Project No. A. Eng. 49 — *A Survey of Agricultural Drain Tile in Ontario, Quality and Specifications,* by F. R. Hore. September 1959.

Research Summaries. July 1959.

Wheels, Hubs and Axles for Farm Trailers, second edition, by Sigfrid Bjerninger and Nils H. Hybbinette. Special Bulletin S2-1958. Written in English. Available from the Swedish Institute of Agricultural Engineering, Ultuna, Uppsala 7, Sweden.

On the Methods of Protecting Drain Pipes and on the Use of Gravel as a Protective Material, by Taneli Juusela. Reprinted from ACTA Agriculture Scandinavica, VIII: 1, 1958. Available from the University of Helsinki, Finland.

Controlling Static Electricity on Cotton During Ginning with an Antistatic Agent, by Clarence G. Leonard. Bulletin ARS 42-39, March 1960. Agricultural Research Service, USDA, Washington 25, D.C.

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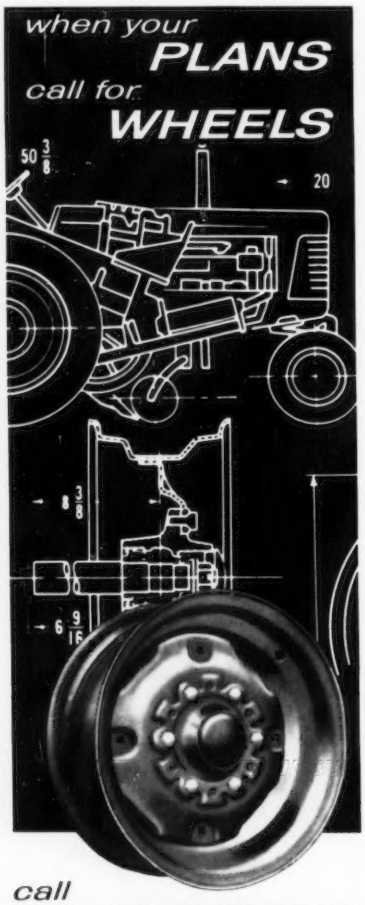

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PERSONNEL SERVICE BULLETIN

Note: In this bulletin the following listings current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency or registration as a professional engineer. Items published herein are summaries of mimeographed listings carried in the Personnel Service, copies of which will be furnished on request. To be listed in this bulletin, request form for Personnel Service listing.

Positions Open (1959)—**December**—O-378-974, 384-975, 370-980, 394-981, 404-982. 1960—**January**—O-441-985, 452-986. **February**—O-4-601, 11-602, 35-605. **March**—O-55-606, 57-608, 66-609, 83-610, 21-611. **April**—O-105-612, 111-613, 114-614, 95-616, 126-617.

Positions Wanted (1959)—**December**—W-390-59, 388-60. (1960) **January**—W-411-61, 426-62, 427-63, 433-64. **February**—W-3-1, 10-2, 15-3, 16-4, 17-5, 5-6, 33-8, 37-9, 30-10. **March**—W-46-11, 63-13, 62-14, 77-15, 69-16, 75-17, 73-18, 74-19, 76-20, 94-21. **April**—W-78-22, 90-23, 99-24, 102-25, 96-26, 110-27, 127-28, 12-29, 117-31, 120-32, 121-33.

NEW POSITIONS OPEN

Project Engineer for design and development work on loaders, with established, growing manufacturer in upper Midwest. Age 25-40. BSAE or BSME. Experience in design and development of industrial loaders for wheel tractors, self-propelled wheel-type loaders or similar industrial or farm equipment. Should be familiar with markets for industrial loaders. Work under staff engineer with responsibility for this type of equipment. Salary $550-700, depending on experience. O-198-618.

Agricultural Engineers (2), for teaching and research in any phase of agricultural engineering. Caribbean island area. Age under 45. BSAE from ECPD accredited curriculum. MSAE or PhD preferred. Experience in teaching or research. Usual personal qualifications for college teaching and research. Excellent opportunity for advancement. Knowledge of Spanish not necessary, but interest in the language desirable. Retirement and fringe benefits. Salary and rank open, depending on qualifications. O-171-619.

Hydraulic Engineer for hydrologic investigations with public agency. Location, north and west of Mississippi River. BS in engineering or equivalent in experience, plus two years professional experience, including one year in hydraulic engineering at GS-7 level. Usual personal qualifications for engineering research in public service. Excellent opportunity for advancement in established agency with continuing requirement for engineers at all levels. Salary, (GS-813-9 rating) $6285 O-187-620.

NEW POSITIONS WANTED

Agricultural Engineer for development, research, service, or writing in power and machinery or soil and water field, with industry or federal agency, anywhere in U.S.A., or in other countries where suitable family living conditions are available. Married. Age 35. No disability. BSAE, 1951, Iowa State University. Additional study in civil engineering. Farm operation 5 years. National Academy of Sciences Aasho Road Test, 4 years. Available on reasonable notice. Salary open. W-101-34.

Agricultural Engineering education specialist for extension, teaching, or research in power and machinery with public service or private foundation. Any location. Married. Age 36. No disability. BS and MS in agricultural education, with double minor in agricultural engineering, 1951 and 1957, Purdue University. Farm background. Agriculturist in Africa 5 years. Agricultural engineering advisor in Burma, 5 years. Available in July. Salary open. W-140-35.

Agricultural Engineer for design, development or research in farm structures or soil and water field with industry in Southwest or South. Married. Age 30. No disability. BSAE, 1953, Texas A & M College. Army enlisted service 2 years. Office engineer in construction work 3 years. Field representative, field support group of aircraft manufacturer, 1½ year. Available on reasonable notice. Salary open. W-129-36.

Agricultural Engineer for extension, teaching, research, sales, service, writing, or management, any branch of agricultural engineering, with industry or public service. Location South or West. Married. Age 35. No disability. BSAE, 1949, Iowa State University. Farm management 11 years. Extension 2 years, including TV, radio and press experience. War enlisted service in Navy, over 2 years. Available on reasonable notice. Salary $6500. W-131-37.

Agricultural Engineer for sales or project engineering in power and machinery field with manufacturer in Midwest. Married. Age 34. No disability. BSAE, 1949, Michigan State University. Product engineer for wheel manufacturer 3½ years. Project engineer for farm equipment manufacturer 1½ years. Territory manager for wholesale distributor of farm equipment, 1½ years. Sales supervisor for wheel manufacturer 2½ years. Available on reasonable notice. Salary $10,000. W-156-38.

Agricultural Engineer for design, development, or research in soil and water field, with consultant or farming operation. Any location. Married. Age 29. No disability. Training in civil engineering and agriculture. Experience with surveyor as rodman and chainman, 2 years. With agricultural tillage service 3 years as equipment operator, surveyor, and grade foreman. One summer in Haiti as technician in charge of land preparation. Field engineer 3½ years with irrigation ditch lining and continuous pipe contractor, in charge of surveying and design. Service with Marine Corps 3 years as engineer equipment operator and construction surveyor. Available on reasonable notice. Salary $600 plus per month. W-175-39.

Agricultural Engineer for design, development, or research, any branch, with industry, any location. Single. Age 28. No disability. BSAE, 1959, Southwestern Louisiana Institute. Experience in engineering 5 months with SCS. Military service 4 years in Air Force. Available on two weeks notice. Salary open. W-119-40.

Soil Conservationist for sales or management in power and machinery or soil and water field with distributor or consultant in Midwest or West. Occasional travel. Married. Age 40. No disability. BS in agriculture, 1942, University of Minnesota. Farm background. Taught vocational agriculture 2 years. Soil conservationist for soil conservation district 16 years, with related responsibility and experience in engineering and extension work. Available in 1961. Salary $7000-8000. W-158-41.

Agricultural Engineer for design, development, research, writing, or management in power and machinery or rural electric field with industry. Any location. Registered Professional Engineer in Pennsylvania. Limited travel. Married. Age 39. No disability. BSME, with honors, 1943, New Mexico College of Agriculture and Mechanic Arts. Aircraft engine and helicopter endurance testing with Air Technical Service Command, 3 years (commissioned service). Several months as engineer with farming company and as draftsman in structural steel design. Sales engineer 2 years with producer of specialized fruit and vegetable machines, one year with producer of vegetable harvesting machines. Available July 1. Salary open. W-172-42.

Agricultural Engineer for design, development, research, or advanced engineering with farm equipment manufacturer. Any location. Married. Age 43. No disability. BSA, 1948; BSME, 1950; MSME, 1951, all at University of Wisconsin. Research in agricultural experiment stations, 6 years, including work on high-speed plowing and hay pelleting. Design and development 3 years with full line farm equipment manufacturer, including experience on harvesting, planting and cultivating equipment. Available on reasonable notice. Salary open. W-182-43.

Agricultural Engineer for teaching or service in power and machinery field, with college or distributor. Pacific Coast area. Occasional travel. Married. Age 44. No restricting disability. BS in agriculture, major in agricultural engineering, 1943, Oregon State College. Farm background. War service in Navy 2½ years as engineering officer on diesel-powered LSM. Teaching farm power and machinery 4 years. Farm equipment service 10 years. Available on reasonable notice. Salary open. W-103-44.

Soil Compaction Bibliography

An Annotated Bibliography on Soil Compaction consisting of over 600 references with a short description of each reference and complete with subject index has been published by the American Society of Agricultural Engineers. The publication is a contribution of the Bibliography Subcommittee of the Soil Compaction Committee of ASAE, with representation from the Soil Science Society of America. Copies are available at $1.50 each ($1.00 to ASAE members). Quantity price for 25 copies or more is $1.00 each. Orders with remittance may be sent to ASAE, 420 Main St., St. Joseph, Mich.

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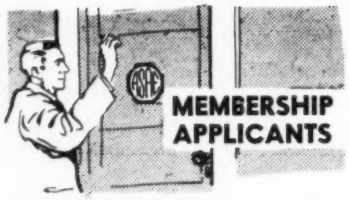

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Alberson, Kenneth G. — Eng. spec., (SCS) USDA, P.O. Box 432, Clayton, N. M.

Alexander, Barrett N.—Engr., Allis-Chalmers Mfg. Co. (Mail) R.R. 1, Box 56, Hartland, Wis.

Attwood, Peter R. — Sr. lecturer in eng. and surveying, Egerton Agr. College, P.O. Njoro, Kenya, British East Africa

Berg, Merritt D. — Asst. sales mgr., Aetna Ball and Roller Bearing Co., 4600 W. Schubert Ave., Chicago 39, Ill.

Cooper, Sam T. — Engr.-aide, Gray Air Force Base. (Mail) Kempner, Texas

Cowie, James T. — Marketing officer, Dept. of Agr., P.O. Box 281, Kampala, Uganda, East Africa

Dickens, Alva W., Jr. — Rural engr., Georgia Power Co., Athens, Ga.

Finley, George A., III — Finco Inc. (Mail) Sugar Grove, Ill.

Frankenberg, Edward V. — Mgr., res. and product dev., Fleco Corp., P.O. Box 2370, Jacksonville 3, Fla.

Frazier, Lamar G. — Agr. engr., Taylor Machine Works. (Mail) Ackerman St., Louisville, Miss.

Gooch, David L. — Plant des. engr., Finco Inc., P.O. Box 968, Aurora, Ill.

Hawks, Keith M. — Farm sales supervisor, Wisconsin Public Service Corp., 600 N. Adams St., Green Bay, Wis.

Johnson, Robert C. — Market analysis, Fenwal Inc., Pleasant St., Ashland, Mass.

Johnston, William R. — Asst. spec., irrigation and soil science dept., University of California. (Mail) 4835 E. Michigan Ave., Fresno 3, Calif.

Kessel, Gene A. — Agr. engr., (SCS) USDA. (Mail) R.R. 3, Box 259A, Morgantown, W. Va.

MacCallum, John J.—Assoc. editor, The Farm Quarterly, 22 E. 12th St., Cincinnati 10, Ohio

Manh-ky, Nghiem — Deputy dir., Agr. Machinery Directorate of Commissariat General for Land Development, 55 rue Tran-Nhat-Duat, Saigon, South Vietnam

Mark, Alexander H. — Chief engr., Massey-Ferguson Ltd., P.O. Box 322, R.P.A., Detroit 32, Mich.

McPherson, Finlay B. — Territory trainee (credit and sales), John Deere Ltd. (Mail) Box 213, Hudson Bay, Sask. Canada

Meng, James L. — Engr.-serv. mgr., Oakes Mfg. Co. (Mail) R.R. 4, Tipton, Ind.

Miramontes, Frank C. — Dir., agr. sales, Pacific Gas and Electric Co., Room 432-A, 245 Market St., San Francisco 6, Calif.

Moody, William F. — Export mgr., Finco Inc., 525 Rathbone Ave., Aurora, Ill.

Newton, Roger B. — Field technician, Hartford Electric Light Co. (Mail) Oak Knoll, Johnson Lane, Durham, Conn.

Reed, T. John — Pres. and des., American Planter Co., N. Third St., Burr Oak, Mich.

Reedman, Norman J. F. — Trainee, Tractor and Implement Div., Ford Motor Co. of Canada. (Mail) Blind Bay, B. C., Canada

Schafer, Robert L. — Agr. engr., (ARS) USDA, Room 215, Agr. Eng. Bldg., Iowa State University, Ames, Iowa

Schenking, John H. — Jr. engr., New Idea Farm Equipment Co. (Mail) 304 E. Walnut, Coldwater, Ohio

Simonsen, Clarence P. — Agr. engr., (SCS) USDA, 118½ N. Broadway, Rochester, Minn.

Sims, Denis A. — Marketing officer, agr. dept., The Protectorate Government of Uganda, P.O. Box 281, Kampala, Uganda, East Africa.

Stenholm, Paul D. — Agr. sales engr., The Goodyear Tire and Rubber Co. (Mail) 4133 N. 56th St., Lincoln, Nebr.

Strickland, Leo E. — Agr. engr., (SCS) USDA, P.O. Box 586, Marianna, Fla.

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DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.

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Thiruvenkataswamy, K. R. — Asst. agr. engr., Soil Conservation Sub Assistants Training Centre, 26 Subramania Mudaliar Road, R. S. Puram Post, Coimbatore 2, Madras State, India

Victoroff, Peter — Steel des., St. Paul Foundry and Mfg. Co. (Mail) 723 N. E. Madison St., Minneapolis, Minn.

Warner, James H. — In charge of fertilizer and ind. equip. section, The Broyhill Co., Dakota City, Nebr.

TRANSFER OF MEMBERSHIP

Adams, Donald E. — Dir., agr. dev., Florida Power and Light Co. (Mail) P.O. Box 191, Palatka, Fla. (Affiliate to Member)

Bennett, George K. — Asst. area mgr., Hydro Electric Power Commission, Drawer 40, Belleville, Ont., Canada. (Associate Member to Member)

Campbell, Lowell E. — Leader of res. instrumentation investigations, Farm Elecn. Branch, (AERD) USDA. (Mail) 10100 Riggs Rd., Adelphi, Md. (Associate Member to Member)

Dickens, James W. — Agr. engr., (AMS) USDA, North Carolina State College, P.O. Box 5906, Raleigh, N. C. (Associate Member to Member)

Fiske, Kenneth V. — Agr. engr., Farm Div., National Safety Council, 425 N. Michigan Ave., Chicago, Ill. (Associate Member to Member)

Haynes, Benjamin C., Jr. — Agr. engr., (ARS, AERD) USDA. (Mail) R.R. 3, Athens, Ga. (Associate Member to Member)

Johnson, Howard P. — Asst. prof., agr. eng. dept., Agr. Eng. Bldg., Iowa State University, Ames, Iowa (Associate Member to Member)

Nixon, Paul R. — Agr. engr., Western Soil and Water Conserv. Branch, (ARS) USDA, P.O. Box 1176, Lompoc, Calif. (Associate Member to Member)

Whitacre, Eugene R. — Proj. engr., International Harvester Co. (Mail) 844 S. Eighth Ave,. LaGrange, Ill. (Affiliate to Member)

STUDENT MEMBER TRANSFERS

Coblentz, Wesley S. — (University of California) Canning Machinery Div., Food Machinery & Chemical Corp. (Mail) 14901 S. Central, Chino, Calif.

Colwick, Allan B. — (Texas Technological College) 121 Park Dr., Stephenville, Tex.

Dawson, Richard C. — (University of California) R.R. 2, Box 255, Escalon, Calif.

Geiger, Claude O. — (Kansas State University) R.R. 2, Parsons, Kans.

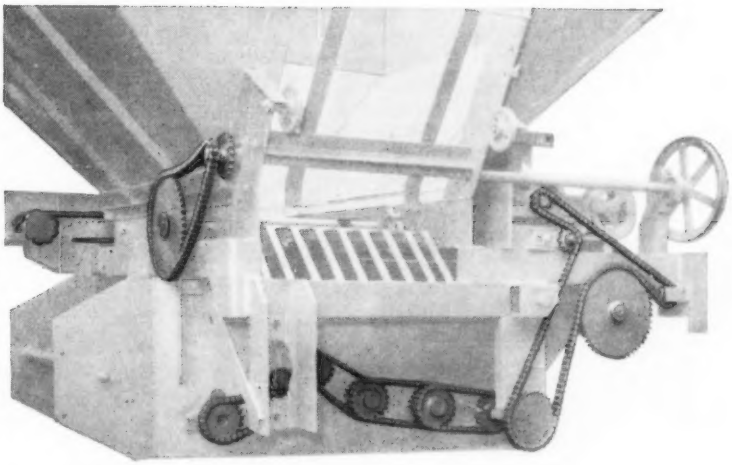
Hawkins, George W., Jr. — (North Carolina State College) 22-H Vetville, Raleigh, N. C.

Hinman, Clinton R. — (Kansas State University) 1849 Anderson, Manhattan, Kans.

Schultz, Finis W. — (University of Illinois) Box 125, Jerseyville, Ill.

Suiter, Adrian L. — (Kansas State University) Macksville, Kans.

Tilley, Allen D. — (Kansas State University) Ralston-Purina Co., Checkerboard Square, Davenport, Iowa



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GEMCO CART BEET HARVESTER

High speed sugar beet harvesting is tough, rugged work—hard on machinery and equipment. The reason General Machine Co., Ogden, Utah builders of the Gemco Cart Beet Harvester uses Whitney Chain and Sprockets for *eleven* different drives is:

"to insure positive driving where high power is required and to eliminate the possibility of loss of power through plugging and slipping in wet, muddy conditions."

The machine is capable of harvesting two or three rows of sugar beets, and mounts on any row crop tractor of 40 to 45 HP drawbar. The bin holds 3 tons of beets which can be unloaded in 1½ minutes.

High strength, maximum fatigue resistance, and extended wear life are characteristics built into Whitney Chain Drives through carefully controlled material selection and advanced manufacturing methods. More and more manufacturers of every type of equipment are putting their confidence in Whitney Chain Drives—the drives that are *built better to serve better.*

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POWER TRANSMISSION DRIVES

. . . New Products

(Continued from page 323)

Fence Building Machine

United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa., has developed a fence building machine for erecting

a wire fence in a "one-pass" operation for a two-man crew. Posts are driven into place. As the tractor and fence erector are driven ahead to the next post location, woven wire fence, or the woven wire and a strand of barbed wire are paid out vertically. Where barbed wire only is needed, as many as five strands can be dispensed.

After three or four posts are driven, a hydraulically operated clamping mechanism holds the wire for stretching. The unit is driven forward to provide the proper tension. The fencing is then attached to the posts and the erection sequence is repeated.

Electronic Gear Tester

Scherr-Tumico Co., 200 Lafayette St., New York 12, N. Y., has introduced a new electronic gear tester using an electronic recorder and transducer. The new tester can be calibrated to any ratio within the limit of the recording tape. One line on the paper can be made to equal from 0.00005 to 0.001 in. depending upon the pitch of the gear being checked.

A driving motor can be furnished to drive the gear being checked. This motor can be wired to the switch controlling the recording tape so that both gear and tape operate in unison, or it can be hooked up to an independent switch if so desired. The electronic recorder can also be furnished without motor drive.

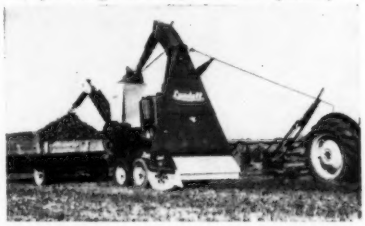
New Sealed Bearing

Rollway Bearing Co., Inc., 541 Seymour St., Syracuse, N. Y., has introduced a new sealed roller bearing, designed for high

capacity, compact size, and protection against premature wear from dirt and chaff in farm equipment applications. The manufacturer reports that such high shock loads of a hay baler plunger crank are carried by the full complement roller, life-lubricated, sealed bearing with a dynamic capacity of 13,400 lb. The bearing has 21 crowned rollers, an ID of 1.750 in., and a spherical OD of 3.3465 in. Feature of the bearing is its buna-N, steel-backed, rubber-bonded seal that prevents dirt, dust, and chaff from abrasive action on the rollers and races.

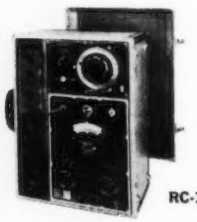
Field Hay Pelleting Machine

Lundell Mfg. Co., Cherokee, Iowa, has completed final field tests on a new field hay pelleting machine, a limited quantity of



which is planned for production this year. The machine is pulled behind a chopper that picks up cured hay from the windrow, chops it and feeds it into the pelleting machine where it is directly formed into pellets which are self-loaded into a trailing wagon. The machine is said to have a capacity of 5 to 6 tons per hour. Various sizes of pellets or wafers can be produced. This year's model will produce 1 x 2 and 2 x 2-in. pellets. Dies for making a pellet or wafer of smaller size will be available at a later date.

BN-2



RC-12C1P

RD-15

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Measure moisture content and soluble salt or fertilizer content with easy-to-use Industrial Instruments Conductivity Bridges!

BOUYOUCOS TRANSISTORIZED MOISTURE METER . . . designed for simple, rapid field testing of available soil moisture. Connect meter to leads from buried soil blocks and read moisture content directly. Completely self-contained, uses 4 inexpensive penlight batteries lasting 2 years. Second meter scale calibrated in ohms measured resistance. BN-2 Meter complete with neck strap and batteries **$96.00**

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MODEL RC-12C1P SOIL MOISTURE BRIDGE . . . high accuracy research instrument incorporating true Wheatstone Bridge circuit with 1000 cps bridge oscillator. Range 0.2 to 2,500,000 ohms with 1% accuracy except at extreme ends of scale. 84" effective scale length and built-in adjustable capacitance up to 21,000 mmf. Electron "eye" null indicator and earphones. Battery-operated and contained in portable carrying case **$288.25**

SOLU BRIDGE SOIL TESTER MODEL RD-15 . . . for laboratory testing of soil extract conductivity and particularly valuable for use by flower growers and in greenhouses. Simplest and easiest to use, the RD-15 is an AC Wheatstone Bridge, line operated, "eye" tube used for null indicator. Calibrated 10-1000 **mhos** x 10^{-5}. Manual temperature compensator 50-100°F. In gray wrinkle steel case, for 115V/50-60 cycle AC operation **$78.00**

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For complete details on these and other conductivity soil testing instruments and accessories write to...

Industrial Instruments;

89 Commerce Road — Cedar Grove — Essex County — New Jersey

. . . Members in the News

(Continued from page 313)

Merritt D. Hill was one of three Michigan citizens who received citations for distinguished service to agriculture during Michigan State University's 45th Annual Farmers' Week. He is vice-president and general manager of the Tractor and Implement Division of Ford Motor Co., at Birmingham, Mich. "He is a strong supporter of Michigan State University and its agricultural program and represents Michigan's agricultural industry on numerous state and national committees," commented Thomas K. Cowden, dean of MSU's College of Agriculture.

Merritt D. Hill

Rolland Z. Wheaton, instructor, agricultural engineering dept., Michigan State University, East Lansing, starting this fall, will be studying at the University of California for two years, working on his Ph.D. degree.

Charles E. Rice, a member of the agricultural engineering staff at the University of Georgia, Athens, recently completed requirements for his Ph.D. degree at Michigan State University.

A. Earl Lee, general manager of marketing and economic research for Massey-Ferguson Ltd., Toronto, Canada, has been appointed chairman of an FEI Foreign Trade Statistics Group, which will investigate sources of information, both public and private, relating to foreign trade.

. . . Manufacturers' Literature

(Continued from page 325)

complete line of fractional horsepower Form G general purpose motors. Sixteen different kinds of fhp motors ranging from motors for machine tools to room air-conditioner motors are shown in NEMA frame sizes 48 through 56. Capacitor-start, split-phase, permanent-split capacitor, shaded-pole and polyphase motors are included.

Bulletin GEC-1049, a 14-page, 2-color illustrated booklet, includes all basic information needed by most motor users. Application chart gives types recommended for various loads and ambient conditions. Tables give dimensions, prices, characteristics and performance data, ordering instructions, modifications and accessories. Typical ratings and construction features are pictured.

Bulletin GEA-7000, a 2-page, 2-color illustrated piece, describes the drum switch for control of single-speed electric motors up to two hp. Application information including ratings, typical connection diagrams and features is given.

Farm Equipment Literature

Farm Equipment Division, Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. — Offers the following 14 pieces of literature:

A 12-page illustrated catalog, No. UT-111 covers the "D" series utility tractor line with its matched equipment. A listing of tractor matched companion equipment is also included.

A 6-page, 2-color reprint entitled "Parallel Terracing" from the "A-C Reporter," an external houseorgan.

An 8-page, 2-color bulletin, No. TL-2203 describes and illustrates the 80 series mowers, and also lists specifications.

A 16-page, 2-color bulletin, No. TL-2193 describes and illustrates models, A, R, and B Gleaner combines. Specifications are also included.

An 8-page, 2-color bulletin, No. TL-2220 describes and illustrates the model AH Gleaner hillside combine. Specifications are also listed.

A 4-page, 2-color bulletin, No. TL-2262 tells about the power feed wagon box and includes specifications.

A 24-page, 4-color brochure, No. TL-2221 describes and illustrates the Big D series, also listing specifications.

A 4-page, 2-color bulletin, No. TL-2227 illustrates and describes rotary mowers and cutters. Also included are specifications.

An 8-page, 2-color brochure, No. TL-2255 describes and illustrates the model 500, 2-row cotton picker and also includes specifications.

An 8-page, 2-color bulletin, No. TL-2228 illustrates and describes the model 72 all-crop harvester and lists specifications.

A 4-page, 2-color bulletin, No. TL-2223 describes and illustrates the hay conditioner, with general specifications given.

A 4-page, 2-color bulletin, No. TL-2235 describes the models 30-S hopper and 30-L conveyor. Specifications for each model are also listed.

A 12-page, 4-color bulletin, No. TL-2200 tells of 50 choices that tailor tractor power to your needs.

An 8-page, 2-color bulletin, No. TL-2230 describes and illustrates the model 77 rake and the model 7 side rake and tedder. Specifications for both models are included.

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Metal Roofing Nails

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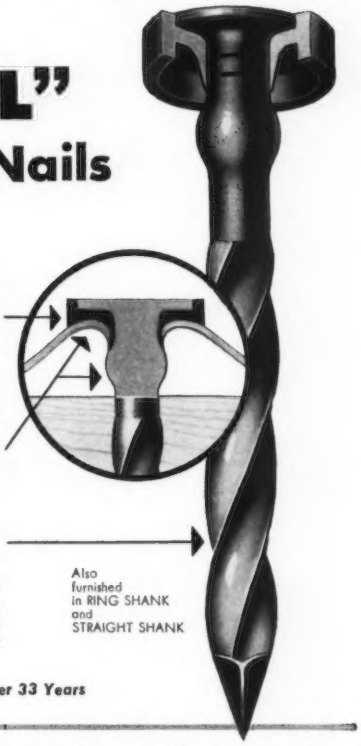

LEAD SEAL—The *only nail* with lead just under the head and down the shank. When the nail is driven, the hole around the nail is plugged with lead and the break in the metal is completely covered, to form a perfect double seal.

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DRIVE SCREW SHANK—The *only nail* that is driven on the steel head. Drive screw shank makes the nail turn and hold like a screw. It holds with a powerful, unyielding grip. Threads are deep and sharp because they are formed after galvanizing.

Also furnished in RING SHANK and STRAIGHT SHANK

Accepted Standard of Quality for Over 33 Years

DENCO Lead-Head Metal Roofing Nails

BRIGHT OR GALVANIZED

6,000 pounds of pressure is used to compress the lead *cold*, both *over* and *under* the steel head of the nail as well as *down the shank*. The lead forms a perfect seal in the hole made by the nail. Heads will not "pop" off from expansion and contraction of roofing nor from wind vibration.

Shipped in 50 lb. cartons. Descriptive literature will be sent immediately upon request.

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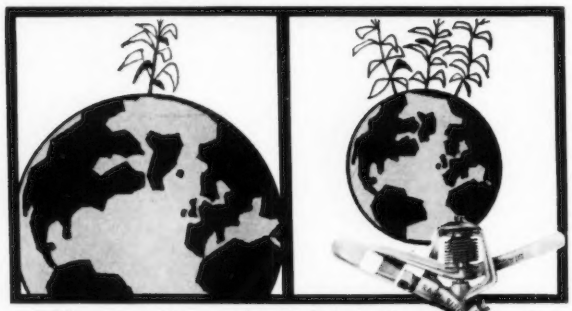

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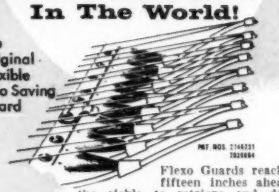

Flexo Guards reach out fifteen inches ahead of the sickle to retrieve and deliver wild heads to auger. Exclusive flexible tines, spaced one and one-half inches apart prevent fall away losses and their backward slope slides the heads quickly to the platform. Flexibility of tines permits heads to engage the ledger plate for clean cut and free, efficient sickle action. Tines are made of extra tough tempered spring steel . . . always return to position.

The convenient sections of approximately two feet in length simply clamp into position. In just thirty minutes a twelve foot machine can be equipped with Flexo Guards. Brackets and set screws are furnished. No sickle adjustment or realignment.

Over half a century of agriculture know-how has been put into Flexo Guards. The same know-how that is being applied to the development of more new ideas to come from Richardson.

FEMA

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travel with the leaders

FOX FORAGE HARVESTER uses Steel Link-Belt Chain on its harvesting attachments. This detachable chain is ideal for drive, conveying and elevating service.

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Steel Link-Belt chain, shown at left, is lightweight, strong and low-cost. Its open hook design simplifies coupling and uncoupling. And like *all* Link-Belt chains it has consistent quality and uniformity in every link.

Link-Belt offers industry's most complete line of drive and conveyor chains, conveyor chain attachments and sprockets. Also, "bonus" services: application counsel, field analysis, laboratory service and others. These services multiply the *value* of Link-Belt chains, *but not the price!* Contact your nearest Link-Belt office or the Indianapolis plant at 220 S. Belmont Street. Ask for 640-page Catalog 1050.

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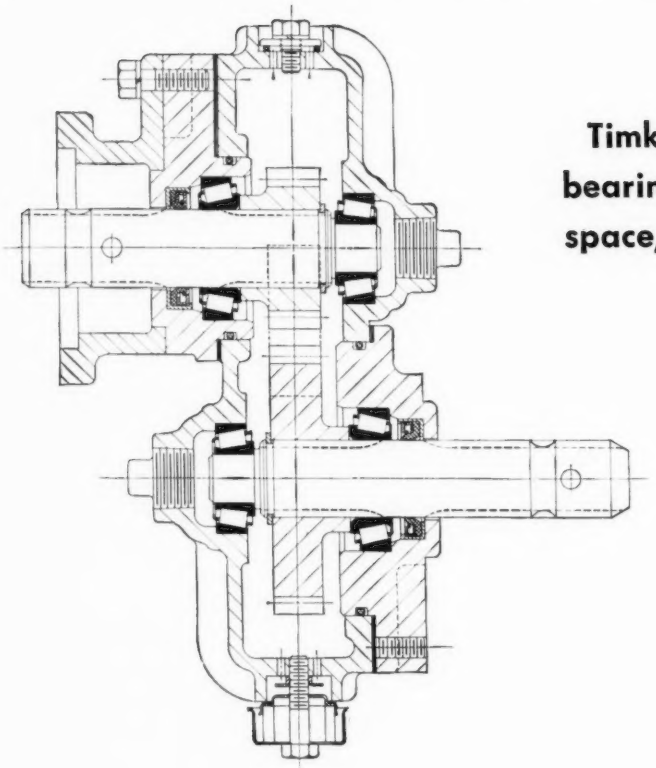
Oliver achieves more economical, compact design in new conversion gear box



Timken® "Green Light" bearings on shafts save space, weight, cut costs

IN designing their new gear box for converting P.T.O. speeds, Oliver engineers achieved greater economy and compactness by mounting the input and output shafts (above) on Timken® "Green Light" tapered roller bearings.

In this mounting, they were able to take advantage of the adjustability of Timken bearings that makes possible liberal tolerances in associated parts. And the resultant uniform, accurate running clearances in Timken bearings maintain gear alignment and concentricity of seals for sealing efficiency, while materially reducing machining time of shafts and housing bores.

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And Timken "Green Light" bearings afford *extra* savings. They're smaller and lighter, save space and weight. They give maximum capacity in minimum space. Because they're mass-produced in standardized sizes, they're lower in cost.

Timken bearings help agricultural engineers solve three big problems: 1) combination loads; 2) dirt; 3) ease of operation. That's why more and more engineers are standardizing on them.

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